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ENVIRONMENT AGENCY AUSTRIA

NPP BORSSELE LTE PHASE 1
ENVIRONMENTAL IMPACT ASSESSMENT

Expert Statement

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Expert Statement

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Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

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SUMMARY

The Borssele NPP consists of one reactor with a capacity of 1,366 MWth and 485 MWe. The NPP has been in operation since 1973, i.e. for over 50 years. According to Art. 15a of the Dutch Nuclear Energy Act, Borssele may continue to produce energy only until the end of 2033, which corresponds to a service life of 60 years. The operating life is now to be extended due to a political decision from 2021. This requires an amendment of the Nuclear Energy Act. An Environmental Impact Assessment (EIA) is being carried out for this amendment; a second EIA phase is also planned.

Austria is participating in this transboundary EIA, as significant impacts from an accident cannot be excluded. The aim of Austria's participation in the process is to give recommendations to minimize, and in the best case eliminate, possible significant adverse impacts on Austria.

Procedure and alternatives

The EIA phase 1 will provide the scope for environmental impacts that need to be discussed in detail in EIA phase 2. The length of the planned lifetime extension was not specified. Some environmental impacts can therefore not be assessed sufficiently, like the resulting amounts of radioactive waste or consequences of a possible parallel operation with the planned new NPP.

In every EIA, alternatives need to be discussed and assessed for their environmental impacts. However, in this EIA, alternatives to nuclear energy were explicitly considered being outside the scope. Also, data on the future energy demand were not presented. A procedure will be held by the responsible Ministry of Economic Affairs and Climate Policy to make an environmental case for the inclusion of nuclear energy in the energy mix, together with planned new build and the nuclear waste management programme – the results of this procedure should be discussed in the EIA phase 2.

The claims of the EIA Report that in general nuclear energy is not more expensive than renewable sources such as wind and solar should be proven, and studies for the lifetime extension costs in comparison with renewables should be provided.

Nuclear waste management

Spent fuel and radioactive waste can have negative environmental impacts. Therefore, an EIA for a lifetime extension needs to evaluate the management of radioactive waste. However, the EIA documents did not provide sufficient evidence for the safe management of spent fuel and radioactive waste.

A final repository for all radioactive waste (LILW and HLW) is foreseen to be operable in 2130. In the meantime, both HLW and LILW will be stored in long-term interim storage facilities. This is a very long timeframe compared to the practice

in other EU countries, this was criticised by the European Commission in its 2024 report on the implementation of Directive 2011/70/Euratom.

The EIA phase 2 should specify how safety and security of all interim storages over more than 100 years will be demonstrated.

Long-term operation of reactor type

The Borssele NPP, one of the oldest operating NPP in the world, is a 2-loop Pressurized Water Reactors (PWR) constructed by the German company Siemens/KWU. Four different constructions lines of the KWU PWR were developed and operated. The Borssele NPP belongs to construction line (CL) 1, both other reactors of this CL have been already shut down permanently in 2003 and 2005, respectively. Besides three younger reactors in Spain, Switzerland and Brasilia, all KWU reactors were shut down permanently. ANVS (2019a) considered this permanent shut down of all German KWU PWRs as a challenge. In 2022, a new Dutch TSO, a consortium of Bel-V, IRSN and Bureau Veritas, was founded to guarantee support in the coming years.

From an Austrian point of view accidents are of special interest. Therefore, the EIA Report should present a plant description including safety relevant features to limit the possible release of radionuclides into the environment. However, the technical design of the Borssele NPP is only described in a very general manner.

The original safety report of the Borssele NPP covered a 40-year operational lifetime, equating to the closure in 2013. However, in 2006, a political agreement ("Borssele Covenant") allowed the operation to 2033 under certain conditions. One requirement is that the Borssele NPP belongs to the top 25% in safety of reactors in the EU, Canada and the USA. To assess whether Borssele NPP meets this requirement, the Borssele Benchmark Committee has been established. In its third report, the committee has selected important safety-related points of the design for comparative evaluation. (BBC 2023) However, other important design features are missing, such as the thickness of the reactor building.

Apart from the fact that the Committee's assessment is not very credible, especially in view of the results of the GRS safety review, a comparison with the safety level of new nuclear power plants should be made to assess the safety level of the Borssele nuclear power plant.

In 2008, the German TSO GRS developed a procedure for comparing the safety of German NPPs of the different ages. The comparison showed that GKN-1, commissioned in 1976 (KWU CL 2) had a safety disadvantage in 17 of 23 assessment objects compared to GKN-2 (1989, KWU CL 4). Weaknesses were found at all levels of the defence-in-depth concept. The comparison also revealed that the average annual event rates at GKN-1 are significantly higher in the area of events with ageing relevance; actually, the number is four times higher.

The ageing management programme of the Borssele NPP has weaknesses as the results of the current IAEA OSART mission revealed. The results of the

OSART mission contradict the statements of the EIA REPORT (2024) that the ageing management effectively prevents physical ageing as well as technological ageing (obsolescence).

The results of the fourth PSR (2013–2022) are not mentioned in the EIA REPORT (2024). Nor does it explain whether the remediation of the identified weaknesses is a prerequisite for the approval of a further lifetime extension.

The 1993 safety report included a statement that the plant design was based on a 40-year operating period. Following an LTO project, approval was granted in 2013 for a lifetime extension. The LTO project was based on now-obsolete IAEA documents.

It was a request by the expert statement to the scoping phase that the regulatory requirements for continued operation beyond 2033 should be described. The extent to which the regulations correspond to the current state of science and technology should also be described. This is only done in a very general way. It is not specified which current IAEA or WENRA documents are applied and to what extent these are binding for a possible approval of an extension of the operation time.

The safety of a plant can only be evaluated against the relevant regulations. If there are no requirements for the important safety aspects such as ageing and protection against internal fires in the Dutch regulations in line with the state of the art, it cannot be guaranteed that the safety level of the plant corresponds to the current state of the art.

Accident analysis

It was already mentioned in UMWELTBUNDESAMT (2023) that the accident analyses should be carried out and described in such a way that it can be verified whether or to what extent accidents could lead to releases of radionuclides that could contaminate the territory of Austria. However, this is not at all the case.

The provided EIA documents give some information about Design Basis Accidents (DBA). The information about Beyond Design Basis Accidents (BDBA), however, is very limited. Neither the accident scenarios nor the possible source terms are provided. According to the EIA REPORT (2024), the calculated core damage frequency has decreased due to backfitting. Information on frequencies for large releases (LRF) is not provided.

The accident analyses in the EIA documents should use a possible source term derived from the calculation of the current probabilistic safety analyses 2 (PSA 2). Even though the calculated probability of severe accidents with a large release is very low, the consequences caused by these accidents are potentially enormous.

Core-melt accidents can cause a failure of the containment. These scenarios are associated with large releases. In 2017, an in-vessel molten core retention by creating a cooling opportunity of the outside of the reactor vessel has been implemented. This could be an important safety improvement. However, the EIA

Report (2024) only mentioned the IVR concepts without providing further details.

To assess the consequences of BDBAs, it is necessary to analyze a range of severe accidents, including those involving containment failure and containment bypass. Such severe accidents are possible for the Borssele NPP. A systematic analysis of BDBAs is missing in the provided EIA documents. In ANVS (2022a), it is stated that for severe accidents the probabilistic safety analysis is used. On the basis of the available information, it is not clear if accidents with a probability of less than 10^{-6} per year are considered.

According to ANVS (2019a), the PSA Level 2 demonstrated that Steam Generator Tube Rupture (SGTR) events with a dry secondary side of the steam generator could cause the largest source terms (up to 50% Cs and I). By a backfitting measure, the possible source term could only be reduced by a factor of 14, this means still a release of 3,6 % of the Cs and I inventory. Furthermore, since the release scenario of a SGTR event cannot be practically excluded, a release of 50% of the Cs and I core inventory is possible. Results of PSA Level 2, published in NEA (2007), show that early releases account for 1.5% of total release frequency, with failure of SG tubes contributing to 60% of these cases.

When the WENRA RLs were updated in 2020, the hazards to be addressed in the safety cases were expanded based on more recent experience and knowledge. Until all potential initiating events have been adequately considered, neither the accident scenarios nor the CDF values determined are sufficiently substantiated.

It is state of the art to use the WENRA “Safety Objectives for New Power Reactors” as a reference for identifying reasonably practicable safety improvements during a LTO project. According to the WENRA safety objective, core melt accidents, which would lead to early or large releases, would have to be practically eliminated. Even if the probability of an accident sequence is very low any additional reasonably practicable design features, operational measures or accident management procedures to lower the risk further should be implemented for the Borssele NPP.

External Hazards

Phase 1 of the EIA solely addresses eliminating legal obstacles to ANVS considering a potential permit application from EPZ for the extension of operations of the Borssele NPP. A comprehensive treatment of external hazards and their effect on nuclear safety besides a few hazards is not in the scope of phase 1. With respect to natural hazards EIA phase 1 only defines a very few focal points for phase 2, all pertaining to effects of climate change:

- Sea level rise, in connection with external flooding.
- Increasing maximum seawater temperature, in connection with reactor cooling.
- Increasing maximum air temperature, in connection with the cooling of safety-related systems.

- Increases of extreme weather events, such as more severe storms.

There is no further information about whether and, if so, how other external hazards will be taken into account in EIA phase 2 and the LTO process. Among the hazards not considered in EIA phase 1, earthquake (vibratory ground motion) and the causally linked seismotectonic hazards liquefaction and dynamic compaction deserve particular attention.

Documents on phase 1 of the EIA further do not provide information on the general process that will be followed up in phase 2 and in the final decision on LTO. It is neither known if LTO will be linked to Periodic Safety Reviews nor if revisions of the hazard assessments for all site-specific external hazards, re-assessments of the design bases for external hazards and adequate DEC assessments are planned to be part of the future LTO process. With respect to the future process, it is recommended to link the LTO decision to Periodic Safety Reviews considering all WENRA Safety Reference Levels relevant to external hazards (Issue TU), design basis and DEC considerations (Issues E and F) and PSR (Issue P).

Accidents with third parties' involvement

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the Borssele NPP. Nevertheless, they are not mentioned in the provided EIA documents. In comparable EIA Reports such events were addressed to some extent. Although precautions against sabotage and terror attacks cannot be discussed in detail for reasons of confidentiality, the necessary legal requirements should be set out in the EIA documents.

Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. In particular, the EIA documents should include detailed information on the requirements for the design against the targeted crash of a commercial aircraft. This topic is in particular important because the reactor building of the Borssele NPP is vulnerable against airplane crashes. The reactor building should protect the plant against attacks from outside. However, the wall thickness at the Borssele NPP is only about 0.6 m to 1.0 m. For example, the EPR's 1.8-meter-thick outer reinforced concrete shell is designed to withstand the impact of a large passenger aircraft.[1] A recent assessment of the nuclear security in the Netherlands points to shortcomings compared to necessary requirements for nuclear security. Low scores for “Insider Threat Prevention” and “Security Culture” indicate deficiencies in these issues. (NTI 2024)

Military action against nuclear facilities is another danger that needs special attention in the current global situation. Furthermore, the increasing availability and performance of drones is raising the potential threat to nuclear facilities.

[1] https://www.grs.de/de/glossar/europaeischer-druckwasserreaktor-epr

Transboundary effects

Neither scenarios for severe accidents nor the possible source terms are provided in the EIA documents. Significant adverse effects for Austria were excluded completely. However, this cannot be verified.

Calculations with the highest possible source term and under the assumption of the most negative weather condition for Austrian territory should be provided in EIA phase 2.

Calculation results for the ground and air contamination in case of a severe core-melt accident would be necessary in order to be able to assess whether radiation protection measures would have to be initiated in Austria.

ZUSAMMENFASSUNG

Das KKW Borssele besteht aus einem Reaktor mit einer Kapazität von 1366 MWth und 485 MWe. Dieses Kernkraftwerk ist seit 1973 in Betrieb, d.h. seit über 50 Jahren. Gemäß Artikel 15a des Atomenergiegesetzes der Niederlande verfügt Borssele über die Genehmigung zur Energieerzeugung bis Ende 2033, womit ein Betriebsalter von 60 Jahren erreicht werden würde. Die Betriebsdauer soll aufgrund einer politischen Entscheidung von 2021 verlängert werden. Dies erfordert eine Änderung des Atomenergiegesetzes, weswegen nun eine Umweltverträglichkeitsprüfung (UVP) dazu durchgeführt wird. Eine zweite UVP-Phase ist ebenfalls vorgesehen.

Österreich beteiligt sich an dieser grenzüberschreitenden UVP, da signifikante Auswirkungen eines Unfalls auf Österreich nicht ausgeschlossen werden können. Das Ziel der Beteiligung Österreichs am UVP-Verfahren ist es, Empfehlungen zur Minimierung und im besten Falle Eliminierung von möglichen signifikanten negativen Auswirkungen auf Österreich zu geben.

Verfahren und Alternativen

In der ersten Phase der UVP wird der Umfang der Umweltauswirkungen festgelegt, die im Detail in der zweiten UVP-Phase diskutiert werden müssen. Die Dauer der geplanten Lebensdauerverlängerung wurde nicht angegeben, weshalb einige Umweltauswirkungen nicht ausreichend bewertet werden. Dazu zählen etwa die Menge an anfallendem radioaktivem Abfall und die Folgen eines möglichen Parallelbetriebs mit dem geplanten neuen KKW.

In jeder UVP sind Alternativen zu diskutieren und deren Umweltauswirkungen zu bewerten. In dieser UVP wurden allerdings die Alternativen zur Kernenergie als außerhalb des Rahmens betrachtet. Ebenso nicht angeführt wurden die Daten zum künftigen Energieverbrauch. Das zuständige Ministerium für Wirtschaft und Klimapolitik wird dazu in einem eigenen Verfahren die Inklusion der Atomenergie in den Energiemix ökologisch begründen, zusammen mit dem geplanten KKW-Neubau und dem Entsorgungsprogramm. Die Ergebnisse dieses Verfahrens sollten in der UVP-Phase 2 diskutiert werden.

Der Nachweis über die Aussage, wonach Kernenergie nicht teurer sei als erneuerbare Energien wie Wind- und Solarenergie, ist zu erbringen. Ebenso sollten Studien vorgelegt zum Vergleich der Kosten der Laufzeitverlängerung mit Erneuerbaren.

Entsorgung radioaktiver Abfälle

Abgebrannter Brennelemente und radioaktive Abfälle können negative Umweltauswirkungen haben. Daher muss eine UVP für eine Lebensdauerverlängerung die Entsorgung der Abfälle prüfen. Doch die vorliegenden UVP-Unterlagen enthalten keinen ausreichenden Nachweis für einen sicheren Umgang mit den abgebrannten Brennelementen und radioaktiven Abfällen.

Ein Endlager für alle radioaktiven Abfälle (LILW und HLW) soll 2130 betriebsbereit sein. In der Zwischenzeit werden sowohl hochaktiver als auch mittel– und niedrigaktiver Abfall in den Langzeit-Zwischenlagern verbleiben. Im Vergleich zur Praxis in anderen EU-Ländern handelt es sich um einen sehr langen Zeitraum, wie auch von der Europäischen Kommission in ihrem Bericht zur Umsetzung der Richtlinie 2011/70/Euratom kritisiert wurde.

In der UVP-Phase 2 sollte dargestellt werden, wie Sicherheit und Sicherung in allen Zwischenlagern für den Zeitraum von über 100 Jahren sichergestellt werden sollen.

Langzeitbetrieb dieses Reaktortyps

Das KKW Borssele ist eines der ältesten in Betrieb befindlichen KKW weltweit. Es handelt sich um einen Druckwasserreaktor (DWR) mit zwei Schleifen vom deutschen Hersteller Siemens/KWU. Vier verschiedene Konstruktionslinien von Druckwasserreaktoren wurden bei Siemens/KWU entwickelt. Das KKW Borssele gehört zur Konstruktionslinie (CL) 1, wobei die beiden anderen Reaktoren dieser CL bereits 2003 bzw. 2005 stillgelegt wurden. Mit der Ausnahme der drei neueren Reaktoren in Spanien, der Schweiz und Brasilien wurden bereits alle KWU-Reaktoren stillgelegt. ANVS (2019a) bezeichnete die Stilllegung aller deutschen KWU DWR als Herausforderung. Im Jahre 2022 wurde eine neue niederländische TSO eingerichtet, ein Konsortium aus Bel-V, IRSN und Bureau Veritas,

Aus österreichischer Perspektive stehen die Unfälle im Fokus, daher sollte der UVP-Bericht eine Beschreibung des Kraftwerks beinhalten, einschließlich der sicherheitsrelevanten Maßnahmen zur Beschränkung der Radionuklidfreisetzung in die Umwelt. Das technische Design des KKW Borssele ist allerdings nur sehr allgemein beschrieben.

Der ursprüngliche Sicherheitsbericht für das KKW Borssele bezog sich auf die 40-jährige Betriebsdauer und die KKW-Stilllegung im Jahre 2013. Allerdings kam es 2006 zu einer politischen Einigung ("Borssele-Pakt"), die den Betrieb bis 2033 unter Einhaltung bestimmter Bedingungen ermöglicht. Eine der Bedingungen lautet, dass das KKW Borssele zu den 25% sichersten Reaktoren in der EU, Kanada und den USA zählen muss. Um festzustellen, ob das KKW Borssele diese Bedingung erfüllt, wurde das Borssele Benchmark Committee eingerichtet. In seinem dritten Bericht hat das Komitee wichtige sicherheitsrelevante Punkte zum Aufsetzen der vergleichenden Bewertung ausgewählt (BBC 2023). Es fehlen allerdings weitere wichtige Designmerkmale, wie etwa die Dicke des Reaktorgebäudes.

Es ist festzuhalten, dass die Einschätzungen des Komitees nicht als glaubwürdig betrachtet werden können, vor allem angesichts der Resultate des GRS-Sicherheitsberichts. Um das Sicherheitsniveau des KKW Borssele bewerten zu können, sollte ein Vergleich mit dem Sicherheitsniveau für neue KKW durchgeführt werden.

Im Jahre 2008 entwickelte die deutsche TSO GRS ein Verfahren zum Vergleich des Sicherheitsniveaus der deutschen KKW mit unterschiedlichem Alter. Der

Vergleich zeigte, dass das KKW Neckarwestheim GKN-1, das im Jahre 1976 genehmigt wurde (KWU CL 2), eine geringere Sicherheit bei 17 von 23 Bewertungsobjekten im Vergleich zu GKN-2 (1989, KWU CL 4) aufwies. Schwachpunkte wurde auf allen Ebenen des gestaffelten Sicherheitskonzepts gefunden. Der Vergleich zeigt auch auf, dass die durchschnittlichen jährlichen Ereigniseintritte bei GKN-1 im Bereich der Ereignisse mit Alterungsrelevanz deutlich höher sind, nämlich vier Mal so hoch.

Das Alterungsmanagementprogramm des KKW Borssele weist Schwächen auf, wie die Resultate der jüngsten IAEO OSART Mission aufzeigten. Die Ergebnisse der OSART Mission stehen im Widerspruch zu den Aussagen im EIA REPORT (2024), wonach das Alterungsmanagement sowohl die physische Alterung als auch die technologische (Obsoleszenz) wirksam verhindern würde.

Die Ergebnisse der vierten PSÜ (2013–2022) werden im UVP-Bericht (EIA REPORT 2024) nicht erwähnt, ebenso unerwähnt bleibt, ob die Behebung der festgestellten Schwachpunkte eine Voraussetzung für die Genehmigung der anstehenden Lebensdauerverlängerung ist.

Der Sicherheitsbericht von 1993 erwähnt, dass das Kraftwerksdesign von einer 40-jährigen Betriebsdauer ausging. Nach der Umsetzung des LTO-Projekts wurde 2013 die Lebensdauerverlängerung gewährt. Dieses LTO-Projekt basierte auf mittlerweile veralteten IAEO-Dokumenten.

Im Fachgutachten zur Scopingphase wurde ersucht, die regulatorischen Anforderungen für die Betriebsfortführung über 2033 hinaus zu beschreiben, wie auch den Umfang, in welchem diese Anforderungen dem aktuellen Stand von Wissenschaft und Technik entsprechen. Dies geschieht nur in sehr allgemeiner Form. Nicht beschrieben wurde, wie weit die aktuellen IAEO oder WENRA Dokumente angewendet wurden und in welchem Umfang diese für die anstehende Betriebsdauerverlängerung relevant sind.

Die Sicherheit des Kraftwerks kann nur anhand der relevanten Vorgaben evaluiert werden. Wenn keine Anforderungen für wesentliche Aspekte der nuklearen Sicherheit wie Alterung und Schutz gegen interne Brände in den niederländischen Vorschriften entsprechend dem aktuellen Stand der Technik vorliegen, so kann nicht garantiert werden, dass das Sicherheitsniveau des Kraftwerks dem aktuellen Stand der Technik entspricht.

Unfallanalyse

Wie bereits in UMWELTBUNDESAMT (2023) erwähnt, sind Unfallanalysen so durchzuführen und zu beschreiben, dass verifiziert werden kann, in welchem Umfang Unfälle zur Freisetzung von Radionukliden führen, in deren Folge das österreichische Territorium kontaminiert werden könnte. Dies ist allerdings nicht erfolgt.

In den zur Verfügung gestellten UVP-Dokumenten finden sich Angaben zu den Auslegungsstörfällen, den Design Basis Accidents (DBA). Zu den Beyond Design Basis Accidents (BDBA), den Auslegungsstörfall überschreitenden Unfällen, findet sich allerdings sehr wenig, wie auch Unfallszenarien oder mögliche Quellterme fehlen. Laut dem UVP-Bericht EIA REPORT (2024) verringerte sich die berechnete Kernschmelzhäufigkeit durch die Nachrüstung. Daten zur Häufigkeit großer Freisetzungen (LRF) wurden nicht angegeben.

Die Unfallanalysen in den UVP-Dokumenten sollten einen möglichen Quellterm verwenden, der von Berechnungen der aktuellen PSA 2 (Probabilistic Safety Analyses) abgeleitet ist. Wenn auch die berechnete Wahrscheinlichkeit für schwere Unfälle mit großer Freisetzung sehr gering ist, so sind doch die Folgen dieser Unfälle möglicherweise enorm.

Kernschmelzunfälle können zu Containmentversagen führen. Diese Szenarien sind mit großen Freisetzungen verbunden. 2017 wurde ein Kernschmelzrückhalt im RDB (IVR) implementiert, indem außerhalb des RDB eine Kühlungsmöglichkeit geschaffen wurde. Dabei könnte es sich um eine wesentliche Sicherheitserhöhung handeln. Allerdings werden im UVP-Bericht (2024) nur IVR Konzepte genannt, ohne weitere Details.

Um die Folgen von BDBAs zu bewerten, ist es notwendig eine Reihe von schweren Unfällen zu analysieren, einschließlich jener mit Containment-Versagen und Containment-Bypass. Derartig schwere Unfälle sind für das KKW Borssele möglich. Eine systematische Analyse der BDBA fehlt in den übermittelten UVP-Dokumenten. In ANVS (2022a) wird festgehalten, dass für die schweren Unfälle eine PSA (Probabilistic Safety Analysis) zur Anwendung kommt. Auf der Grundlage der verfügbaren Informationen ist unklar, ob Unfälle mit einer Wahrscheinlichkeit unter 10^{-6} pro Jahr in Betracht gezogen worden sind.

Laut ANVS (2019a) zeigte die PSA Level 2, dass Dampferzeugerröhrenbrüche (SGTR) mit einer trockenen Sekundärseite des Dampferzeugers die größten Quellterme bewirken könnten (bis zu 50% Cs und I). Durch Nachrüstung könnte der mögliche Quellterm nur um den Faktor 14 reduziert werden, was noch immer eine Freisetzung von 3,6% des Cs und I Inventars bedeutet. Weil ein Freisetzungsszenario durch einen Dampferzeugerröhrenbruch nicht praktisch ausgeschlossen werden kann, ist eine Freisetzung von 50% des Cs- und I-Kerninventars möglich. Die Ergebnisse der PSA Level 2, veröffentlicht in NEA (2007), zeigen, dass die frühen Freisetzungen für 1,5% der gesamten Freisetzungshäufigkeit verantwortlich sind, wobei ein Versagen der Dampferzeugerröhren zu 60% dieser Fälle beiträgt.

Im Jahre 2020 wurden in den WENRA RL die Gefährdungen, die in den Sicherheitsnachweisen zu betrachten sind, auf Basis der jüngsten Erfahrungen und neuestem Wissen aktualisiert. Solange nicht alle potentiellen initiierenden Ereignisse entsprechend betrachtet wurden, sind weder die Unfallszenarien noch die CDF-Werte ausreichend begründet.

Bei der Identifizierung von vernünftigerweise durchführbaren Sicherheitsverbesserungen gilt die Anwendung der WENRA "Safety Objectives for New Power Reactors" als dem aktuellen Stand der Technik bei einem LTO-Projekt entsprechend. Laut dem WENRA Sicherheitsziel müssen Kernschmelzunfälle, die zu einer frühen oder großen Freisetzung führen, praktisch ausgeschlossen werden. Selbst wenn die Wahrscheinlichkeit von Unfallabfolgen sehr gering ist, sollten zusätzliche vernünftigerweise durchführbare Designmerkmale, Betriebsmaßnahmen oder Unfallmaßnahmen zur Risikoreduktion beim KKW Borssele realisiert werden.

Externe Gefährdungen

In Phase 1 der UVP geht es ausschließlich um die Beseitigung rechtlicher Hindernisse, die der ANVS bei der Prüfung eines möglichen Genehmigungsantrags der EPZ auf Lebensdauerverlängerung im Wege stehen.

Eine umfassende Behandlung der externen Gefährdungen und deren Auswirkungen auf die nukleare Sicherheit sind mit Ausnahme einiger weniger Gefährdungen nicht im Rahmen von Phase 1.

In der UVP-Phase 1 werden nur sehr wenige Fokuspunkte für die Phase 2 definiert, die sich alle auf die Auswirkungen des Klimawandels beziehen:

- Ansteigen der Meeresspiegel in Verbindung mit externen Flutungen.
- Anstieg der maximalen Meerestemperaturen in Bezug auf die Reaktorkühlung.
- Anstieg der maximalen Lufttemperaturen in Bezug auf die Kühlung der sicherheitsrelevanten Systeme.
- Anstieg des Eintritts von extremen Wetterereignissen, wie etwa von schweren Stürmen.

Es liegt keine weitere Information darüber vor, ob und falls ja, wie in der zweiten Phase der UVP und des LTO-Verfahrens zusätzliche externe Gefährdungen betrachtet werden. Unter den in Phase 1 der UVP nicht betrachteten Gefährdungen sind Erdbeben (vibrierende Bodenbewegungen) und die kausal verbundenen seismotektonischen Gefährdungen von Verflüssigung und dynamischer Verdichtung von besonderer Bedeutung.

Die Dokumente zur UVP-Phase 1 enthalten weiters keine Informationen über die allgemeinen Verfahren, die in Phase 2 und der finalen Entscheidung über LTO eingehalten werden. Weder ist bekannt, ob die LTO an die Periodischen Sicherheitsüberprüfungen (PSÜ) geknüpft sein werden oder ob Revisionen der Gefährdungseinschätzung für alle standortspezifischen externen Gefährdungen, Neubewertungen der Auslegung für externe Gefährdungen und adäquate DEC Bewertungen als Teil des künftigen LTO-Verfahrens vorgesehen sind. Für dieses künftige Verfahren wird empfohlen, die LTO-Entscheidung an die PSÜ unter Beachtung aller WENRA Safety Reference Levels mit Relevanz für externe Gefährdungen (Issue TU), Auslegung, DEC Themen (Issues E und F) und PSÜ (Issue P) zu knüpfen.

Unfälle mit Beteiligung Dritter

Terroristische Angriffe und Sabotageakte können signifikante Auswirkungen auf Nuklearanlagen haben und zu schweren Unfällen führen – auch auf das KKW

Borssele. Dennoch werden diese in den UVP-Dokumenten nicht angeführt. Bei vergleichbaren UVP-Berichten werden diese in einem bestimmten Umfang berücksichtigt. Wenn auch die Maßnahmen zur Verhinderung von Terror und Sabotage aufgrund der Vertraulichkeit nicht im Detail diskutiert werden können, sollten die relevanten rechtlichen Vorgaben in den UVP-Unterlagen genannt werden.

Angesichts der immensen Konsequenzen potentieller Angriffe wären Informationen über Terrorattacken von hohem Interesse. Daher sollten die UVP-Dokumente detaillierte Angaben über die Anforderungen an die Auslegungen gegen gezielte Flugzeugabstürze eines Verkehrsflugzeugs beinhalten. Diese Frage ist insofern bedeutend, als das Reaktorgebäude des KKW Borssele gegenüber Flugzeugabstürzen vulnerabel ist. Das Reaktorgebäude sollte das Kraftwerk gegen Angriffe von außen schützen, doch liegt die Wanddicke beim KKW Borssele bei nur 0,6 bis 1,0 m. Zum Vergleich verfügt der EPR über eine 1.8m dicke äußere Stahlbetonhülle gegen die Auswirkung eines großen Passagierflugzeugs.

Eine jüngst in den Niederlanden durchgeführte Bewertung der nuklearen Sicherung zeigte Schwächen bei den benötigten Vorkehrungen in diesem Bereich auf. Die niedrigen Werte für "Insider Threat Prevention" und "Security Culture" verweisen auf diese Mängel. (NTI 2024)

Militärische Attacken auf Nuklearanlagen sind eine weitere Gefahr, die in der gegenwärtigen Weltlage besondere Aufmerksamkeit benötigt. Auch die steigende Verfügbarkeit und Leistungsfähigkeit von Drohnen erhöht die mögliche Gefährdung von Nuklearanlagen.

Grenzüberschreitende Auswirkungen

Weder Szenarien für schwere Unfälle noch möglichen Quellterme werden in den UVP-Dokumenten angeführt, signifikant negative Auswirkungen für Österreich wurden gänzlich ausgeschlossen. Diese Behauptung kann allerdings nicht verifiziert werden.

Berechnungen mit dem größten möglichen Quellterm und unter Annahme der ungünstigsten möglichen Wetterlage für das österreichische Staatsgebiet sollten in der 2. Phase der UVP durchgeführt werden.

Die Berechnungsresultate für die Boden- und Luftkontamination bei einem schweren Kernschmelzunfall sind notwendig, um feststellen zu können, ob Strahlenschutzmaßnahmen für Österreich in Kraft gesetzt werden müssen.

1 INTRODUCTION

The Borssele NPP consists of a pressurized water reactor with a capacity of. 1,366 MWth and 485 MWe. The NPP has been in operation since 1973, i.e. for over 50 years. According to Art. 15a of the Dutch Nuclear Energy Act, Borssele may continue to produce energy only until the end of 2033, which corresponds to a service life of 60 years.

The operating life is now to be extended due to a political decision from 2021. This requires an amendment of the Nuclear Energy Act. An Environmental Impact Assessment (EIA) is being carried out for this amendment; a second EIA phase is also planned.

The Netherlands have notified Austria according to Art. 3 of the Espoo Convention (1991) and Art. 7 of the EIA Directive (EU 2014). A transboundary EIA is conducted under Dutch law and the Espoo Convention. The authority in charge is the Ministry for Economy Affairs and Climate Policy. Operator of the NPP Borssele is N.V. Elektriciteits Productiemaatschappij Zuid-Nederland (EPZ).

The Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology commissioned the Environment Agency Austria to coordinate the assessment of the submitted EIA documents in the framework of this expert statement. In this expert statement, questions and preliminary recommendations are formulated.

Austria is participating in this transboundary EIA, as significant impacts from an accident cannot be excluded. The aim of Austria's participation in the process is to give recommendations to minimize, and in the best case eliminate, possible significant adverse impacts on Austria.

A scoping procedure was carried out for this EIA process in 2023, an expert statement was prepared. (UMWELTBUNDESAMT 2023) In this scoping expert statement, recommendations for the scope of the EIA were formulated.

2 PROCEDURE AND ALTERNATIVES

2.1 Treatment in the EIA documents

The fourth cabinet in the Netherlands under the former Prime Minister Rutte decided in its coalition agreement to keep the Nuclear Power Plant (NPP) Borssele in operation beyond 2033. The Nuclear Energy Act defines in Art. 15a that the Borssele lifetime is restricted to 2033. The Act is therefore now to be amended.

The Environmental Impact Assessment (EIA) is conducted in **two phases**. Phase a1, which is now ongoing, deals only with the amendment of the Nuclear Energy Act. It discusses the main environmental impacts of the operation of Borssele, and a first assessment of environmental impacts of the lifetime extension period. Furthermore, it defines a list of topics for EIA phase 2. EIA phase 2 will be on the permit procedure, where further technical studies along with the results of EIA phase 1 will lead to a decision. (EIA REPORT 2024, p. 11)

For the EIA phase 1, the following **EIA documents** were presented[2]:

- EIA REPORT (2024): Environmental Impact Assessment. Amendment of the Nuclear Energy Act. Ministry of Economic Affairs and Climate Policy. 14. June 2024.
- DRAFT EXPLANATORY STATEMENT (2024): Konzept der Begründung. Attachment 1 of EIA Report. Concept Memorie van Toelichtig art 15a Kew.
- DUTCH NUCLEAR ENERGY ACT AMENDMENT DRAFT (2024): Gesetzesvorlage über die Änderung des niederländischen Kernenergiegesetzes für die Verlängerung der Betriebsdauer des Kernkraftwerks Borssele. Pdf, 2 Seiten.
- EIA REPORT GERMAN SUMMARY (2024): Umweltverträglichkeitsprüfung (Zusammenfassung). Änderung des Niederländischen Kernenergiegesetzes [Kernenergiewert]. Ministerium für Wirtschaft und Klima. 14. Juni 2024.

The text for the **amendment of Art 15a** consists of four paragraphs, in which the license holder will be authorized to apply for a license change for Borssele. For this, he will have to submit studies on the environmental impacts of the lifetime extension and an updated safety report. The nuclear regulator will have to review this license application. The prolongation of the operation will be possible after 2033 in case of acceptance by the nuclear regulator. (DUTCH NUCLEAR ENERGY ACT AMENDMENT DRAFT 2024)

DRAFT EXPLANATORY STATEMENT (2024) explains that Art 15b of the Nuclear Energy Act foresees an unlimited operation, but for Borssele an exception has been made with Art 15a limiting operation until 2033. This was due to a political

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[2] These documents can be downloaded here: https://www.umweltbundesamt.at/kkw-borssele-lte2023-1

decision in 2006 resulting in inclusion of Art 15a into the Nuclear Energy Act in 2010.

The decision for an EIA considered the Espoo Convention (ESPOO CONVENTION 1991), the Espoo Guidance on the applicability of the Convention to the lifetime extension of NPP (ESPOO GUIDANCE 2021), the decision of the Espoo Implementation Committee and the Meeting of the Parties from 2023 on Kozloduy 5&6, and the EU EIA Directive 2014/52/EU. Moreover, the decision of the European Court of Justice 2019 concerning an EIA for the lifetime extension of Doel 1&2 was considered. It was discussed if a Strategic Environmental Assessment (SEA) would be necessary for the amendment of the law, but the conclusion was drawn that it would be sufficient to conduct the EIA in two phases to combine plan and project focus. This also reflects the decision of the Aarhus Convention Compliance Committee and the Meeting of the Parties of the Aarhus Convention from 2021, that the public did not have sufficient participation possibilities when Art 15a was included in the Nuclear Energy Law in 2010. (DRAFT EXPLANATORY STATEMENT 2024)

The **timeline of lifetime extension procedure** is described in Section 2.3 of the EIA Report. A comprehensive list of political decisions and necessary steps in the permit procedure is given in table 2.1 (EIA REPORT 2024, p. 26ff.), including:

- The decision on the amendment of the Nuclear Energy Act is foreseen in 2025.
- In parallel, the political decision by the responsible Minister on building two new NPP is also foreseen in 2025.
- The Ministry of Infrastructure and Water Management is currently working on the nuclear waste management programme (NPRA) that will come into effect in 2025.
- Technical studies for the lifetime extension are to be finished by 2025.
- The permit application will start in 2025 and shall be finished by 2029. During this phase, the EIA phase 2 will be conducted.
- Contracts with fuel suppliers and waste management organisation COVRA will be made between 2025 and 2029.

The EIA Committee of the Netherlands has given its opinion in the scoping stage of the EIA. The EIA Report discusses what has been implemented from this opinion. (EIA REPORT 2024, p.19) Among others, the EIA Committee suggested to no longer assess three alternatives (10 year lifetime extension, 20 years, and unlimited), but to examine the existing environmental impacts at the Borssele site and extrapolate those to 2033 and beyond.

Alternatives

The Netherlands aim to be climate neutral by 2050, and that in 2035 no CO_2 should be emitted by energy production. In this EIA procedure the question of whether nuclear energy should be part of the energy mix is not considered. (EIA REPORT 2024, p. 12)

The EIA Report refers to the National Energy System Plan (NPE) which was approved in December 2023. The NPE calls for scaling up of solar, wind and nuclear energy sources to their maximum capacity; this means two new NPP plus lifetime extension of Borssele. The NPE also does not address the general question of whether nuclear should be part of the energy system. (EIA REPORT 2024, p. 23)

The EIA Report informs that a procedure will be started in which the environmental case for the inclusion of nuclear energy in the energy mix will be defined by the Ministry of Economic Affairs and Climate Policy in 2024. In this procedure, also the planned new build and the nuclear waste management programme will be taken into account. (EIA REPORT 2024, p. 26)

In 2021, the Netherlands produced 122 billion kWh with imports increasing and domestic production decreasing – fossil fuels were reduced, combined with a smaller increase of renewables. According to the Climate and Energy Outlook, significantly more electricity will be needed in the future due to electrification of industry and mobility. (EIA REPORT 2024, p. 24) Borssele produces about 3% of the electricity consumed in the Netherlands annually.

Nuclear energy is reported to be on a general level not more expensive than renewables such as wind and solar; costs for lifetime extension are described as one of the cheapest and fastest ways of continuing to generate CO_2-free electricity. (EIA REPORT 2024, p. 24)

A zero option is briefly mentioned, which is called “reference situation”. This option refers to the situation if Borssele is shutdown end of 2033 followed by decommissioning.

2.2 Discussion

The EIA phase 1 has the goal to identify possible environmental impacts of the lifetime extension of Borssele based on the results of the scoping phase, but only in limited detail. In EIA phase 2, more detailed environmental assessment should take place. This expert statement defines topics that need to be addressed in more detail in EIA phase 2.

Alternatives

An important aspect is the duration of the license validity, if it will be unlimited or limited. The amendment text of Art 15a includes no limit. Information on the duration of the possible lifetime extension is missing in the EIA documents. Besides the mentioning of the zero alternative, no options were discussed for the duration of lifetime extension. This was due to a recommendation of the Dutch EIA Committee. However, if the length of the planned lifetime extension is not specified, some environmental impacts can therefore not be assessed sufficiently, like the resulting amounts of radioactive waste or consequences of a possible parallel operation with the planned new NPP.

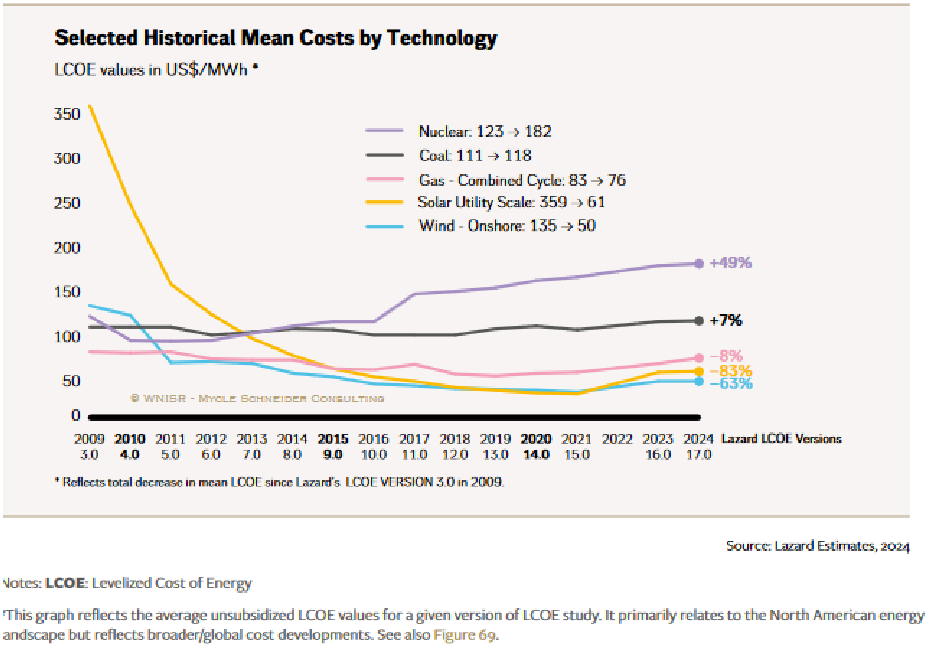
No alternative options for energy production are discussed and assessed for their environmental impacts in the EIA documents. This should be part of EIA phase 2.

The announced procedure by the Ministry of Economic Affairs and Climate Policy to be made in 2024 on the environmental case for the inclusion of nuclear energy in the energy mix, together with planned new build and the nuclear waste management programme, could provide the missing information for the EIA phase 2.

The claim of the EIA Report that nuclear energy is not more expensive than renewable sources such as wind and solar, is no longer true, as the following figure from the latest World Nuclear Industry Status Report summarises.

Figure 1: The declining costs of renewables versus traditional power sources

Selected Historical Mean Costs by Technology



Source: WNIRS 2024

Not only the costs for NPP new build but also for lifetime extension should not be described as one of the cheapest and fastest ways of continuing to generate CO_2-free electricity without presenting any studies in this regard.

Coverage of recommendations formulated by UMWELTBUNDESAMT (2023)

The EIS should describe if and how a decision on the EIA will have to be respected by those administrative bodies and institutions, which will deal with the long-term operation of the plant licensing.

The EIA Report states that the EIA results will be considered by the regulator ANVS in the application procedure of the permit. How the results will be considered is not specified.

- Include a fourth alternative: No lifetime extension and therefore shutdown of the plant by 2033

A reference situation is briefly described and should be elaborated for its environmental impacts in EIA phase 2.

- For each of the four alternatives an analysis on the electricity generation options should be presented.

Alternatives for lifetime extension duration periods were not described in the EIA documents.

- The electricity generation system will change in the upcoming future. Due to the increase of the use of renewable energy generation sources load following operation might be a challenge for the plant. The EIS should discuss if and how the plant will be integrated into a generation system, which could require load following operation. A description of the assessment of safety relevant components of the plant should elaborate how stress factors, due to load following operation, had been analysed and what were the related results.

This has not been described in the EIA documents.

- The EIS should describe the surrounding area of the NPP and take into consideration what has changed since its commissioning. This description should focus on the development of settlements, industrial activities in the surrounding of the plant, the development of traffic, mainly transport of goods and products (street, rail, aviation and ship), which could pose a risk to the plant.

The EIA Report gives a short description of facilities in the direct vicinity of the Borssele site. These activities include construction of underground high-voltage connections, facilities for hydrogen transport and storage, construction of a high-voltage substation, and the possible construction of a new NPP. (EIA REPORT 2024, p. 32f.)

No information is given on previous changes in the region.

- Re-evaluate the risks associated with other industrial facilities near the Borssele NPP as described in IAEA No. SSG-79. The EIA Report should include a map of the location with all facilities and their infrastructure and transportation routes with hazardous and potentially dangerous goods for the NPP
- For each of the Alternatives 1, 2 and 3 the surrounding of the plant, mainly influenced by the plant as well as areas and activities, which could influence the plant operation should be described in detail.
- These descriptions should focus on the foreseen development of changes - relevant for the timeframe of the intended lifetime extension of the plant -

in settlements, industrial activities and traffic of goods and products (street, rail, aviation and ship), which could pose a further risk to the plant.

- Depending on the timeframe intended in Alternatives 1, 2 and 3 the projected development of the surroundings should be included in the EIS as to whether and how it will affect the plant operation, both during normal operation and in the event of an accident.
- No map was included.

No information was given on possible influences of the environment of the NPP.

2.3 Conclusions, questions and preliminary recommendations

The EIA phase 1 deals with the scope for environmental impacts that need to be discussed in detail in EIA phase 2. The decision to not discuss alternative options for the duration of the lifetime extension makes it difficult to assess some aspects linked to operation times like ageing, radioactive waste, the consequences of a parallel operation with the possible new NPP etc.

In every EIA, alternatives need to be discussed and assessed for their environmental impacts. However, in this EIA, alternatives to nuclear energy were explicitly considered being outside the scope. Also, data on the future energy demand were not presented. A procedure will be held by the responsible Ministry of Economic Affairs and Climate Policy to make an environmental case for the inclusion of nuclear energy in the energy mix, together with planned new build and the nuclear waste management programme – the results of this procedure should be discussed in the EIA phase 2.

The claim of the EIA Report that nuclear energy is not more expensive than renewable sources such as wind and solar should be proven.

Questions:

Q1: *For how long is the lifetime extension foreseen?*

Preliminary recommendations

PR1: It is recommended that alternatives are discussed and assessed for their environmental impacts in the EIA phase 2. This encompasses alternatives for energy production but also for different durations of lifetime extensions.

PR2: The electricity generation system will change in the upcoming future. Due to the increase of the use of renewable energy generation sources load following operation might be a challenge for the plant. The EIA phase 2 should discuss if and how the plant will be integrated into a generation system, which could require load following operation. A description of the assessment of safety relevant components of the plant should elaborate how stress factors, due to load following operation, had been analysed and what were the related results.

PR3: EIA phase 2 should include an assessment of all facilities and their infrastructure and transportation routes with hazardous and potentially dangerous goods that could lead to a danger for the NPP Borssele.

3 NUCLEAR WASTE MANAGEMENT

3.1 Treatment in the EIA documents

Spent fuel and high level waste

Spent fuel form Borssele has been sent to reprocessing in La Hague/France since 1976. Per year approximately 8.5 canisters á 180 litres of vitrified and 8 canisters of compacted high level waste (HLW) result from reprocessing, this is in total less than 3 m^3 per year. Based on existing contracts, the number of canisters being returned to the Netherlands is regulated. The canisters are stored on-site in the so-called high level radioactive waste treatment and storage building (HABOG). Both the heat producing vitrified and the non-heat producing compacted HLW canisters are designed for long-term storage. The heat-producing canisters are cooled passively by natural air convection. (EIA REPORT 2024, p. 42f, 100)

Ten additional years of operation could result in 56 m^3 HLW. The Dutch waste management organisation COVRA has currently taken into account the possible lifetime extension of Borssele in its inventory calculations of radioactive waste. Enough interim storage capacity is available according to these calculations. (EIA REPORT 2024, p. 101)

The operator decides if the spent fuel should be reprocessed. In 2022, the Dutch government stated its preference for reprocessing. (EIA REPORT 2024, p. 96)

Low- and intermedium level waste

Low- and intermedium level waste (LILW) is directly handed over to COVRA. (EIA REPORT 2024, p. 43) LILW are collected in stainless steel barrels, which are then compressed and transferred in a steel storage barrel and after that packed in concrete.

COVRA collects all radioactive waste centrally. Waste is to be stored above ground for at least 100 years.

Ten additional years of operation could result in 700 m^3 LILW. There is enough interim storage capacity available. (EIA REPORT 2024, p. 101)

For the future Borssele decommissioning, COVRA estimates 1,900 m^3 LILW. (EIA REPORT 2024, p. 101)

Final repository

HLW and LILW that is still radioactive after the interim long-term storage will be stored in a deep geological repository (DGR). (EIA REPORT 2024, p. 96) Research for a DGR has been carried out since the 1970ies in rock salt and Boom Clay. Recent research activities are the OPERA research programme and a study from the Rathenau Institute. (EIA REPORT 2024, p. 101)

3.2 Discussion

Spent fuel and high level waste – interim storage

In the EIA Report, volumes are provided for the additional HLW resulting from the lifetime extension. No information on nuclides is provided. Information on the total activity of HLW (excluding spent fuel) is 2,895 PBq. (NATIONAL REPORT 2024, p. 40)

The EIA Report informs that there would be enough interim storage capacity for the lifetime extension at the HABOG, but without specifying the capacity and how much of the capacity has already been filled.

The inventory according to the national report (which is the report for both the Joint Convention and the national report on progress of the national waste management programme) is 100.2 m^3 of HLW excluding spent fuel as of 31 Dec 2023. (NATIONAL REPORT 2024, p. 40)

Reprocessing is the favoured option for spent fuel from old and possible new NPP in the Netherlands, including the Borssele lifetime extension. The valid agreement with France encompasses only spent fuel that is produced until 2033. Orano will accept spent fuel only until 2049, and the return of the vitrified and the compacted HLW to the Netherlands has to take place until end of 2052. (NATIONAL REPORT 2024, p. 26) For the spent fuel from lifetime extension, no contract with Orano/France exists yet.

The HABOG is designed for storage of at least 100 years. (NATIONAL REPORT 2024, p. 98) Until a possible final repository will be operable in 2130, the HLW already disposed in the interim storage will need to be stored for more than 100 years, and the HLW from the lifetime extension for at least 80 or 90 years, depending on the timeframes for reprocessing and for transferring to the DGR.

Low- and intermedium level waste – interim storage

The same is true for LILW resulting from the lifetime extension: Information was only given on the volume of the LILW expected from lifetime extension, but no details on nuclides, activities, form and types of waste. The EIA Report informs that there is enough capacity in the existing interim storage without providing any numbers to specify it.

The total inventory of LILW in the Netherlands is according to the national report 12,867 m^3 with a total activity of 10,240 TBq as of 31 Dec 2023, stored in the LOG facility. (NATIONAL REPORT 2024, p. 40) No capacity data are provided for the LOG facility. The construction of a new interim storage for LILW, the so-called MOG, has started end of 2023 and is planned to start operation in 2025. (NATIONAL REPORT 2024, p. 17) It is not clear where the LILW from the lifetime extension will be stored: at the LOG or the MOG, what capacities these storage facilities have.

Final repository

A deep geological disposal is foreseen to be operational in 2130, with decision making in about 2100. (NATIONAL REPORT 2024)

In its 2024 implementation report, the European Commission criticises several aspects of the nuclear waste management in the EU. The EC mentions that "the targets set in some national programmes are not sufficiently ambitious and envisaged long implementation periods that risk burdening future generations." (EC REPORT 2024, p. 16) The Netherlands intend to have a final repository operable only decades after other EU countries. This encompasses not only a final repository for HLW, but also for LILW.

This long timeframe until a final repository could become operable results in the need for long-term interim storage. It needs to be proven that all interim storage facilities are sufficiently safe and secure for more than 100 years.

Another option for the Netherlands is a shared repository solution, which is seen as a possible option to become available during the long-term interim storage period. (NATIONAL REPORT 2024, p. 28). However, no country has yet announced that it would be willing to build a multinational final repository on its territory.

On the shared disposal option that the Netherlands also pursue, the EC criticises that "[s]everal Member States keep an option for shared disposal solutions with other countries. However, this may lead to deferral of decisions rather than acceleration especially because of import bans in numerous Member States." (EC REPORT 2024, p. 16) In the case of the Netherlands, the combination of the very late start for the final repository and the shared solution option does not accelerate reaching operable back-end options.

3.3 Conclusions, questions and preliminary recommendations

Spent fuel and radioactive waste can have negative environmental impacts. Therefore, an EIA for a lifetime extension needs to evaluate the management of radioactive waste. However, the EIA documents did not provide sufficient evidence for the safe management of spent fuel and radioactive waste.

A final repository for all radioactive waste (LILW and HLW) is foreseen to be operable in 2130. In the meantime, both HLW and LILW will be stored in long-term interim storage facilities. This is a very long timeframe compared to the practice in other EU countries, this was also criticised by the European Commission in its 2024 report on the implementation of Directive 2011/70/Euratom.

The EIA phase 2 should specify how safety and security of all interim storages over more than 100 years will be demonstrated.

Questions:

Q2: *What capacity has the HLW storage HABOG for the different types of HLW?*

Q3: *To which degree is the HABOG filled now, and what is expected until 2033?*

Q4: *When will a contract with Orano be concluded for the reprocessing of spent fuel from the lifetime extension? What will happen if no contract can be concluded?*

Q5: *Will LILW from the lifetime extension be stored at LOG or MOG?*

Q6: *What capacity have the LILW interim storage facilities LOG and MOG?*

Q7: *To which degree is the LOG filled now, and what is expected until 2033?*

Q8: *What is the design life for HABOG, LOG and MOG?*

Q9: *How will the safety and security of all interim storage facilities be proven for more than 100 years be demonstrated?*

Preliminary recommendations

PR4: It is recommended to provide in the EIA phase 2 sufficient evidence for safe management of the radioactive waste from lifetime extension including the high level waste from reprocessing.

4 LONG-TERM OPERATION OF REACTOR TYPE

4.1 Treatment in the EIA documents

Chapter 3.1 presents a general description of the Borssele nuclear power plant. The Borssele nuclear power plant is located approximately 1.4 kilometers north-west of the village of Borssele, in the province of Zeeland. The plant is located directly behind the sea dike. Elektriciteits Productiemaatschappij Zuid-Nederland (EPZ) operates the nuclear power plant, which has been operational since 1973. The Borssele nuclear power plant is a pressurised water reactor with a net electrical power output of 485 MW. (EIA REPORT 2024)

Borssele Nuclear Power Plant Covenant

Chapter 3.3.3 discusses the Borssele nuclear power plant in comparison with other nuclear power plants. It is explained that a new nuclear power plant is generally safer than (existing) nuclear power plants built earlier. Thanks to improved understanding of accident scenarios, new nuclear power plants are designed to cope with major accidents. However, the Borssele nuclear power plant has been modified in the light of the new insights and requirements.

In 2006, the Borssele Nuclear Power Plant Covenant was signed, in which the owner of the Borssele NPP committed to ensuring that the Borssele NPP would be among the 25% safest technically comparable power reactors in the European Union, the United States and Canada – the so-called safety benchmark. To this end, in 2008 a commission of independent international experts was set up, the Benchmark Commission, which verifies compliance with the safety benchmark every five years and reports back to the parties to the covenant. The safety benchmark of Borssele nuclear power plant from 2023 concludes as follows: *The Commission has compared the safety of 220 nuclear power plants using the comprehensive methodology developed. Based on that comparison, the Commission has unanimously concluded that the Borssele nuclear power plant is among the 25% safest water cooled and water moderated reactors in the EU, US and Canada.* (EIA REPORT 2024)

Safety barriers

It is explained that the Borssele nuclear power plant has five safety barriers that protect people and the environment against radiation and radioactive substances. Barriers 1 to 3 are the nuclear fuel tablet, the fuel rod and the primary system.

Barrier 4 is the containment: The primary loop is enclosed in a steel sphere that is centimeters thick. This ensures that if the earlier barriers fail, the radioactivity cannot escape outside the installation. The sphere is a strong airtight structure and can withstand internal gas and steam explosions, thus averting emissions from the primary loop in the event of an accident.

Barrier 5 is the reactor building: The nuclear systems are enclosed in the reactor building. The building represents the final physical barrier between the radioactive substances in the core and the environment. Conversely, the reactor building is the barrier to threats from outside. (EIA REPORT 2024)

Improvements after the Fukushima accident

It is explained that after the 2011 Fukushima accident, numerous improvements have been implemented, for example (EIA REPORT 2024):

- A new 380 kV connection to the national power grid has been constructed.
- Extra cooling capacity has been added to the fuel storage system.
- An external cooling system has been provided for the reactor pressure vessel (RPV), which involves flooding the cavity between the RPV and the concrete enclosure with water. External reactor vessel cooling can be necessary in extreme situations to ensure that a melting core remains contained within the RPV.
- Additional equipment such as mobile pumps and emergency power generators have been purchased which can be connected at various points in the nuclear power plant.

Ultimate Heat Sink

The ultimate heat sink is Western Scheldt. For the event that water from the Western Scheldt should not be available, a backup system was installed in 1997 that makes use of eight boreholes to the saline groundwater. With the help of powerful underground pumps, saline groundwater can be pumped up in order to transfer the decay heat from the primary loop, via an interim cooling system. (EIA REPORT 2024)

Periodic safety review (PSR)

It is stated that the Regulation on Safety of Nuclear Facilities stipulates that a safety evaluation must take place at least once every ten years, which involves assessing whether the design basis requirements are met and new safety improvements can be identified. International developments in the field of nuclear safety and radiation protection are included in this safety evaluation.

The last fully completed 10-yearly safety evaluation (including improvement measures) is the 10EVA13. In addition to improvement measures ensuing from the normal 10EVA process, improvement measures were also identified based on studies carried out as part of the 10EVA13 project following the complementary safety analysis (‘stress test’) conducted following the Fukushima accident. These improvement measures have since been implemented. Of the 10-yearly safety evaluation for the period from 2013 to 2022, the evaluation phase was completed in 2023. The measures have to be implemented by the end of 2027.

The modifications made to the Borssele nuclear power plant and the organisation over the past decades, based on these periodic safety evaluations, can be divided into several main themes. The guiding principles include the expansion of emergency power supplies, system modifications and the expansion of core cooling capabilities. Below are some examples of the modifications that have been made over recent decades. (EIA REPORT 2024)

Expansion of safety systems:

- Bunkered additional water injection systems for cooling the reactor.
- Additional accident instrumentation for processing information during accidents.
- Emergency water system with groundwater wells.
- Spatial separation of safety systems to enhance independence.
- Increased autarky time through automatically operating safety systems and having sufficient diesel and water supplies.
- Increasing resilience to external events such as flooding, earthquakes, kerosene fires and an explosive gas cloud from the Western Scheldt.
- Filtered overpressure protection of the containment during accidents.
- Passive hydrogen recombiners to prevent explosions during accidents.

Ageing Management

Chapter 8.4.2 deals with the "ageing management": It is stated that ageing management involves three different kinds of deterioration, namely conceptual, technical and physical ageing. These different forms are described, together with how EPZ interprets them. (EIA REPORT 2024)

Conceptual ageing occurs, for example, when the state of the art is improved. Managing this kind of obsolescence is covered by 10-yearly safety evaluations (10EVA) at the Borssele nuclear power plant. Permit requirement C.19 lays down that EPZ has to conduct a PSR over the period from 2013 to 2022. To this end, EPZ submitted in advance a final plan of action and an assessment framework to ANVS for approval. This ensures that ANVS can check in advance whether the PSR is carried out in accordance with applicable legislation and regulations (ANVS-2018/20254).

The second type of ageing is **technical ageing**, which is usually called obsolescence. Examples of obsolescence are when the knowledge and skills within or beyond the organisation are no longer sufficient to maintain the relevant systems or parts can no longer be supplied.

At EPZ, this kind of obsolescence is consigned to maintenance operations, which includes managing spare parts. Spare parts have been kept in stock for critical plant parts since 1973. Essential components of safety devices, pumps and control systems are managed in a controlled manner.

To maintain and enhance the knowledge and skills in the organisation, every employee is trained according to the qualification requirements associated with his/her position. An important part of the periodic training for control room staff is the so-called 'simulator training'. Training takes place in the control room simulator. The control room simulator is currently being moved from its original location in Germany to the EPZ site and will be available there going forward. These training sessions are not optional; if performance is unsatisfactory, the control room member of staff stands to lose his/her qualification for the job.

Chapter 8.4.2.3 describes **physical ageing:** Materials deteriorate due to use and/or the passage of time. This is known as physical ageing, and it occurs in all elements, in so-called active as well as passive components. The physical ageing of passive components involves, for instance, the process material becoming brittle under the influence of irradiation, corrosion or fatigue due to, for instance, thermal transients that can compromise integrity and cause leakage.

Physical ageing is controlled by doing maintenance on the plant in line with its design and according to applicable regulations. This applies to passive as well as active components. At the Borssele nuclear power plant, this is laid down in the EPZ maintenance programmes in accordance with NVR NS-G-2.6. The plant programmes are:

<u>Maintenance</u>: EPZ uses a widely recognised, structured analysis method, the failure mode and effects analysis (FMEA) when determining these factors. In addition, probabilistic safety evaluations (PSAs) are actively used. PSAs are used to determine the effect of maintenance work on the core melt frequency.

<u>Surveillance (functional tests)</u>; EPZ carries out periodic functional tests of safety-related structures, systems and components (SSCs) in accordance with scenarios and procedures. The tests monitor whether the SSC in question can continue to fulfil its safety function without interruption based on specific acceptance criteria.

<u>In-service inspection (ISI)</u>: EPZ has an ISI programme that stipulates periodic non-destructive testing of the reactor vessel and other primary systems. The purpose of these investigations is to demonstrate that the required condition of the systems is maintained. Non-destructive testing is carried out on the reactor vessel, welds, material transitions and connections of the primary system. Ultrasonic and X-ray technology is used to closely examine the components for imperfections as an indication of incipient cracking or reduction in the wall thickness. The inspection intervals vary depending on the radiation dose, mechanical and thermal loads, but the entire system is inspected at least once every ten years.

EPZ has a specific ageing management process in place in accordance with both NVR NS-G-2.12 as stipulated in the permit as well as the current IAEA Guideline SSG-48 *Ageing management and development of a programme for the long-term operation of nuclear power plants* (IAEA, 2018). It is an integrated activity that involves assessing and recording physical ageing and assessing whether the existing ageing management is adequate or needs to be adjusted. Internal information from operations and maintenance and external information, derived from research results, and being a member of the World Association of Nuclear Operators (WANO), the International Generic Ageing Lessons Learned (IGALL) and specific meetings and conferences held by the IAEA. (EIA REPORT 2024)

In the process, tasks are laid down in procedures, whereby a plan-do-check-act cycle is applied as described in the SSG-48 (IAEA, 2018). There are various ageing phenomena, including various forms of corrosion, wear and tear or thermal ageing. Several specific ageing phenomena are set out in EPZ's permit. These phenomena are listed, and an indication is given of how they are controlled:

Reactor pressure vessel (RPV) embrittlement: An extensive testing programme has been running since the construction of the reactor. In the process, the extent of the neutron irradiation, on the one hand, is determined. A prognosis of the material behaviour is made based on this. On the other hand, the actual material behaviour is verified by testing specimens (of the same material as the reactor wall) exposed to neutron irradiation in the reactor. The results were taken into account in the renewed analyses carried out as part of the 2014 operating life extension, i.e. the LTO B project. The results demonstrate that the RPV has generous safety margins as far as brittle break is concerned. These safety margins will continue to apply if the design operating life of the Borssele nuclear power plant is extended from forty to sixty years.

System material fatigue: The primary system, which includes the RPV and the pipelines, is made of various kinds of steel. Stresses occur in the material due to mechanical and thermal loads. These loads come from variations in pressure and temperature, the components' own weight, and so on. The system is designed in such a way that the components are dimensioned so that the stresses that occur are well below the permissible standard stress of the material. This means that the stresses that occur will never lead to the failure of these components.

A fatigue monitoring system (FAMOS) was installed in 2010 to monitor actual load fluctuations. This safeguards the principles and, with that, the validity, of the fatigue analyses. By monitoring actual fluctuations in the load, FAMOS gives better insight into how the actual load fluctuations relate to the load fluctuations in the design in fatigue analyses. Load fluctuations that occur are evaluated each year and the results are shared with the supervisory authority, ANVS.

Qualification of accident-resistant electrical equipment: The Borssele nuclear power plant has electrical equipment to control and monitor the process. Special design requirements apply to some of this equipment, because it has to continue to function properly during and after a design basis accident under the environmental conditions prevailing at the time, such as increased temperature, pressure, relative humidity and higher radiation levels. This equipment is known as 'accident-proof equipment' and is qualified for the special design requirements. A limited technical lifespan is permitted for this equipment, provided it is replaced in good time. This kind of equipment is also relatively easy to replace. Components for which a qualified residual service life of at least five years cannot be demonstrated require corrective measures in the form of requalification or replacement with qualified components.

The aim of ageing management is to ensure that the Borssele nuclear power plant can be operated safely until 2034. An investigation is currently under way to assess whether the nuclear power plant can be operated safely after 2033. In particular, the technical operating life is determined by the expectation of how irreplaceable components, such as the reactor pressure vessel, can remain in operation safely. Based on previous studies, these components are not showing evidence of problematic deterioration and therefore do not constitute an impediment to extending the operating life safely. Those components that can be replaced will have to be assessed to determine whether it is necessary or desirable to replace them. Before EPZ decides whether or not to operate the nuclear power plant after 2033, EPZ is going to conduct extensive technical studies to see if it can be done safely. (EIA REPORT 2024)

Before the Borssele nuclear power plant can continue operating after 2033, it will have to be demonstrated whether all safety-related systems, structures and components are in place and reliable for the anticipated operating period. This will be done under the auspices of ANVS as the supervisory authority and based on technical investigations, safety studies in accordance with the legislation, regulations and guidelines applicable at the time. Specifically, this means that the long-term operation (LTO) will be implemented for the anticipated operating period, following the development of LTO programmes for nuclear power plants as described in the relevant IAEA guidelines. Besides the technical aspects of obsolescence, this concerns the organisational, procedural and administrative aspects.

EIA Phase 2

The EIA outlines the current situation at KCB. Based on the results of EIA Phase 1, it can be concluded there are no direct obstacles to the proposed legislative amendment beforehand. In Phase 2 of the EIA, all environmental impacts must be reconsidered and assessed again, for the purpose of the permit application for the intended extension of the operational time. Based on these studies, it will be clear whether any physical adjustments to the nuclear power plant are necessary. (EIA REPORT 2024)

KCB meets the legal criteria in terms of controlling design basis accidents and their potential radiological consequences. It also meets the risk criteria for individual and group risks for beyond design basis accidents. The safety analyses underpinning this will have to be renewed for operations after 2033, based on the regulations and guidelines in force at the time.

Before KCB can continue operating beyond 2033, all systems, structures and components with a nuclear safety function must be demonstrated to be available and reliable for the anticipated period of operation. This will be done under the auspices of ANVS as the supervisory authority and based on technical investigations, safety studies in accordance with the legislation, regulations and guidelines applicable at the time.

The above extrapolation leads to the following environmental focal points for EIA Phase 2 regarding the operating period beyond 2033:

- Updating the safety analyses for testing the control of design accidents and their possible radiological consequences, and the risk criteria for the individual and group risk for off-design accidents.
- Updating the assessment of any transboundary effects of accidents.
- Demonstrating that the safety-relevant cooling systems, even in accident situations, can sufficiently cool Western Scheldt water at the maximum possible water temperature to ensure nuclear safety.
- Demonstrating that air cooling in safety-relevant buildings, including in accident situations, can provide sufficient cooling at the maximum possible air temperature to ensure nuclear safety.
- Demonstrating that adequate protection of KCB is in place against the maximum seawater levels to be assumed to ensure nuclear safety.
- Demonstrating that adequate protection of KCB is in place against the maximum wind speeds to be assumed to ensure nuclear safety.
- Demonstrating that the effects of ageing of systems, components and structures with a nuclear safety function are controlled for the intended operating life extension.
- Demonstrating that in addition to the technical aspects of ageing, the organisational, procedural and administrative aspects have also been dealt with adequately in the LTO programme.

4.2 Discussion

Pressurised water reactors (PWR), like used at the Borssele NPP are the most common type of nuclear reactor. The Borssele NPP is one of the oldest operating NPP in the world. The operator and Licence Holder (LH) of Borssele NPP is the company EPZ. PZEM and Essent/RWE are shareholders of EPZ, and own 70% respectively 30% of the shares. (ANVS 2022a)

KWU constructions lines

The Borssele NPP, a 2-loop Pressurized Water Reactors (PWR) constructed by the German company Siemens/KWU started commercial operation in 1973. In Germany, four different constructions lines of the KWU PWR were developed and operated. Both reactors that belong to the first construction line, like the Borssele NPP, have already been shut down permanently in 2003 and 2005 respectively. Obrigheim (357 MWe) was operating from 1968 to 2005, and Stade (672 MWe) from 1972 to 2003. Even the reactors belonging to the second construction line have been shut down permanently in 2011. The seven KWU PWR belonging to the construction lines 3 and 4 have been permanently shut down between 2015 and 2023. Only the Swiss NPP Gösgen (construction line 2), in operation since 1979, Trillo 1 (Spain), in commercial operation since 1988 and the NPP Angra 2 (Brasilia) are still in operation.

Potential effects from German phase-out

In ANVS (2019a) it is stated that the main future challenge is the potential effects from the German phase-out. In 2013, on initiative by the ANVS the regulatory bodies from Germany, Spain, Switzerland and the Netherlands came together to form an informal regulator group 'KWUREG'. Since then, the group has had annual meetings. In the Netherlands, both licensee and regulator have cooperated with German institutions and organisations. According to ANVS (2022a), since 2022 ANVS has a new TSO, a consortium of Bel-V, IRSN and bureau Veritas., this should guarantee proper support in the coming years. However, this challenge is not mentioned in the EIA REPORT (2024), nor is its supposed solution and the experience to date.

Safety comparison of two KWU reactors of different age

In 2008, the German Association for Plant and Reactor Safety (Gesellschaft für Anlagen- und Reaktorsicherheit - GRS) developed a procedure for comparing the safety of German nuclear power plants of different ages. For this purpose, "assessment objects" (AO) were defined, on the basis of which a safety comparison was carried out (BMU 2008). A total of 23 assessment objects were defined for the safety comparison between the two units of the Neckarwestheim nuclear power plant. GKN-1, commissioned in 1976, belongs to the KWU construction line 2 and GKN-2, commissioned in 1989, belongs to the KWU construction line 4.

For 17 of these 23 AOs, GKN-2 had a safety advantage. Weaknesses were found at all levels of the defence-in-depth concept. Among other things, it was found that

- At level 1, GKN-1 had fewer reserves for preventing malfunctions than GKN-2 for all of the higher-level aspects for operating and design features that were examined. In this respect, conceptual disadvantages and the materials used play a particularly important role.
- At level 4, GKN-1 has lower safety margins than GKN-2, in particular due to the weaker design against an aircraft crash.

Overall, GKN-1 is generally much less protected against design-basis accidents because its entire safety design is outdated. There is an increased risk that safety systems will fail in the event of an accident. This is because the safety systems and components are not sufficiently independent of each other in terms of location and process technology according to the current state of the art.

The comparison also showed that the average annual event rates at GKN-1 are significantly higher than at GKN-2. Due to the increase in experience and knowledge gained 13 years later, there is a higher quality in design and manufacture. This is a major reason for the higher event rate of GKN-1. In particular, in the area of events with ageing relevance, the number of events at GKN-1 is four times higher. Events with demand or false actuation of a safety device, often caused by maintenance errors or failures in the electrical and instrumentation and control technology, occurred about ten times more frequently at GKN-1. At GKN-1, there were five times as many events requiring the emergency power system. (INRAG 2021)

The 2006 Borssele Covenant

In 1994 Dutch Parliament decided to phase out the plant by 2003, ten years earlier than the life span of 40 years anticipated by design. The decision was legally challenged and revoked. While its operating license is valid for an indefinite period, its initial safety report covered a 40-year operational lifetime, equating to the closure of the plant in 2013. However, in late 2006, the owner, its shareholders, and the Dutch Government reached an agreement, formalized as the "Borssele Covenant", to allow the operation of the reactor to continue until 31 December 2033 provided certain conditions are met. (WNISR 2024)

One requirement is that the Borssele NPP keeps belonging to the top 25% in safety of the fleet of water-cooled and water-moderated reactors in the European Union, Canada and the USA. To assess whether Borssele NPP meets this requirement, the Borssele Benchmark Committee has been established. The Committee reported its findings for the first time in September 2013. The third report of the Committee was published in 2023. (BBC 2023)

For each of the following design features and their sub-features, design solutions were identified and scoring criteria attributed reflecting their impact on design safety:

- Redundancy and diversity of safety systems
- Design of containment
- Availability of bunkered systems
- Severe accident management
- Design of spent fuel pool

The Committee concluded: The results of the benchmarking indicate that from the design point of view, KCB remains well within the top 25% safest reactors. As in 2013 and 2018, the Committee is still of the opinion that KCB's favourable score in the design review is the result of prudent original design, but even more because of continuous safety improvement programmes that have taken place since 1986, in particular due to periodic safety reviews. However, topics like thickness of the containment or physical separation of safety systems are not assessed.

For the other topics of the assessment, the comparison was made more or less on the basis of a qualitative assessment by the Committee:

- KCB is situated in the middle of the range, with seven plants of the peer group being better and five being worse than KCB. Nevertheless, it was concluded that KCB's safety performance in plant operations, maintenance and safety management is comparable to its peers in the top 25% in operational performance.

- The scope of the ageing management review consisted of a comparison of KCB's ageing management programme against ageing management programmes of five peer plants. The Committee concluded that the ageing management of KCB is comparable to that of its peers.
- The Committee concludes that the way KCB treats siting aspects in the periodic safety review is similar to most plants in the benchmark and better than some. The Committee is confident that siting does not negatively affect the overall safety ranking of KCB.
- The Committee noted that KCB continues to be very active in the area of Safety culture, thus the Committee concludes that safety culture at KCB is equal or better than at the other nuclear power plants visited.

The committee has selected important safety-related points of the design for comparative evaluation. However, other important points are missing, where Borssele would have scored poorly, such as the thickness of the containment and the spatial separation of the safety systems. The qualitative assessment of other relevant safety aspects is not very meaningful. As such, the evaluation gives the illusion of safety rather than a real safety assessment.

It was already recommended by UMWELTBUNDESAMT (2023) that the EIS that based on 2014/87/Euratom Article 8a existing nuclear installations should reach a safety level as close as possible to new nuclear power plants. The approach to be in line with 2014/87/Euratom should be presented in the EIA Report. The EIA Report should describe the differences between Borssele NPP in comparison to new nuclear power plants, with respect to the exclusion of early and large releases. This should include a description of releases of nuclides under design base and beyond design base accidents in comparison to new nuclear power plants.

Implementation of Defence-in-Depth

In the Netherlands the IAEA standards play an important role in the regulatory framework. IAEA standards are applied in amended form as NVRs. According to the ANVS (2019a), currently the NVRs that are applicable contain the amended IAEA design requirements NVR-NS-R1 and guides NVR-NS-G-1.1 through G-1.13 (IAEA 2005) and NVR 2.1.1, an amended version of SS 50-SG-D1, which is published in 1979, and not valid anymore. It is explained that except the NVR 2.1.1, the NVR's for design have been formally introduced as licence conditions for the Borssele NPP in 2011. The NPP has to comply with these as far as reasonably achievable.

The defence-in-depth concept to be applied is defined in NVR-NS-R-1 'Safety Requirements for Nuclear Power Plant Design'. According to ANVS (2022a), the Borssele NPP meets the requirements regarding the defence-in-depth concept. However, it is explained that redundancy and separation were not completely established in the design stage (1970) as it should according to insights later.

During the implementation of measures of the first periodic safety review (1994-1998) a lot of measures were taken to improve the situation.

Redundancy is applied to important safety systems to cope with the so called single failure criterion. For example: the low pressure safety injection and residual heat removal system has in both loops two systems. In addition, the electrical system has been divided into two lines, each having an emergency diesel generator, but in addition backed up by a third DG.

As the Borssele NPP was built in the 1970s, in the original design physical separation was limited. In the first PSR, a significant effort was put into creating a physical separation between redundant systems of the two loops. This separation was further improved in the second and third PSR. Separation is applied to prevent common cause failure by for instance fire or flooding or by the effect of a failure on a neighboring redundant system. Separation was for instance improved by moving two of the three DGs that were all located in the same building, to a different location in a new building. Where relocations of redundant systems were not possible, other solutions were found; e.g. local physical separation was applied between these systems to reduce the risk of common cause failures. This statement shows that physical separation is not always possible.

The impact of common cause failures can be limited by the application of diversity. As a result of PSR a diverse cooling system for the reactor and fuel pool consisting of number of groundwater pumps have been installed. It was mentioned that stress test measures like the use of mobile equipment could also be considered as an application of diversity.

However, ANVS (2023a) only mentions the parts of the plant where redundancy, physical separation and diversity have been improved since operations began. The parts of the plant where this is not technically possible or is avoided for economic reasons are not mentioned.

From a safety perspective, it is furthermore very important that the safety systems of different levels of the Defence in Depth concept are independently of each other. This means that if there is a hazardous situation or an accident, a safety system must not fail simply because another safety system fails. This important requirement was not fully implemented in older plants, such as the Borssele nuclear power plant.

It was already a request by the expert statement to the scoping phase that the technical design should be described. (UMWELTBUNDESAMT 2023) However, this is done only in a very general manner.

Topical Peer Review of Fire Safety and Fire Protection concept (TPR 2)

In 2023, the National Assessment Report (NAR) of the Netherlands for the Topical Peer Review 2 (TPR 2) on the Fire Safety and Fire Protection concept and its implementation was published. This national report has been prepared by the Authority for Nuclear Safety and Radiation Protection (ANVS), and as far as it concerns the requested information on the fire protection aspects of the nuclear installations, it was developed in close cooperation with the licensees of these installations. The peer review process of TPR 2 is still ongoing. However, some weaknesses of the Borssele NPP are already revealed (ANVS 2023a, 2024a):

- Only the electrical components of the fire detection system are of nuclear safety class 1A (safety relevant). The mechanical components of the fire-fighting systems are of safety class 4 (lowest safety class).
- The high-pressure fire extinguishing network in the controlled area is earthquake resistant. Other fire extinguishing systems are not.
- The design of the plant relies on maintaining the 60-minute fire-resistant compartments. There is an option to increase the fire resistance of the doors to 90 minutes, but since the rest of the compartment would remain at a 60 minute limit, the option seemed impractical, considering economic factors as well.

4th and 5th Barriers

The EIA REPORT (2024) explained that the primary loop is enclosed in a steel sphere that is centimeters thick (barrier 4). This should ensure that if the earlier barriers fail, the radioactivity couldn't be released out of the containment. The sphere is a strong airtight structure and can withstand internal gas and steam explosions, thus averting emissions from the primary loop in the event of an accident. However, the wall thickness, design pressure and design temperature are lower compared to the containment vessels in newer design lines of the KWU reactors. (BMU 2010)

The nuclear systems are enclosed in the reactor building Barrier 5. The building represents the final physical barrier between the radioactive substances in the core and the environment. The reactor building should protect the plant against attacks from outside. However, the wall thickness is only about 0.6 m to 1.0 m. Already the reactor buildings of the KWU PWR constructions line 3 and 4 have a wall thickness of 1.8 m. Nowadays, a wall thickness of about 2 m is considered to be adequate.

Long Term Operation (LTO)

The Safety Report of 1993 contained a statement that the design of the plant was based on an operating period of 40 years starting from 1973. Therefore, the EPZ had to apply for a licence approving Long Term Operation (LTO). The LTO project resulted in a licence application that was submitted for regulatory review in 2012, the license was granted in 2013. The LTO project was carried out using IAEA Safety Report Series 57, which was published in 2008. However, this IAEA document is now superseded by the IAEA Safety Standards Series No. SSG-48 (IAEA 2018).

The LTO process was supported by a limited scope IAEA SALTO mission in 2009. At the end of the LTO programme and in the phase of the licensing a full-scope SALTO mission was carried out in May 2012. The final LTO licence was given including the provision to complete the measures based on the SALTO mission recommendations before the end of 2013. (ANVS 2022a) Again, a Pre-SALTO Mission to Borssele for the 19 to 28 November 2024 is planned. (IAEA 2024)

For the Borssele NPP the possibility of further lifetime extensions had already been discussed by EPZ in November 2020. The idea was to extend the operational lifetime from 2033 by another 10 or 20 years. Further operation of Borssele would require the amendment of the Nuclear Energy Act. In December 2022, operator EPZ applied for a grant to conduct technical feasibility studies on the operation of Borssele beyond 2033. (WNISR 2024)

Topical Peer Review of Ageing Management in 2017 (TPR 1)

In 2017, all EU Member States and some neighbouring states carried out a National Assessment of Ageing Management Programmes (AMPs) of nuclear installations under the auspices of ENSREG. The regulatory and supervisory authorities of the participating countries have defined specific requirements for the AMP and implemented them in national legislation or guidelines, in accordance with the IAEA safety standards and WENRA SRLs. However, due to the different construction methods of the NPPs and the differences in the regulations, the AMPs in the individual countries are different (ENSREG 2018a).

According to ENSREG (2018b): a requirement for the AMP was not fulfilled by the Netherlands: During extended shutdown periods, relevant ageing mechanisms are not identified and appropriate measures taken to limit incipient ageing processes or other effects.

Corrosion is the main damage mechanism that can lead to leaks in concealed piping. The recently introduced AMP, which is based on inspections in all countries, has not yet proven effective according to ENSREG. Non-destructive testing methods to detect local corrosion in inaccessible pipework, suitable for use with long lengths or complicated geometry, have not yet been introduced (ENSREG 2018a).

According to ENSREG (2018b), the inspection of safety-related pipe penetrations through concrete structures is not part of the AMP in Netherland. Furthermore, opportunity checks of inaccessible pipes were not carried out when the pipes are accessible for other purposes.

All in all, the National Action Plan (NAcP) in September 2019 formulated ten (sub)actions for NPP Borssele to remedy the shortcomings. In addition, seven (sub)actions were formulated for the regulatory body ANVS. According to ENSREG (2024a), all actions for the Borssele NPP are completed.

However, the ageing management programme has still weaknesses as the results of the current IAEA OSART missions revealed.

IAEA OSART Missions

The IAEA, at the request of the Authority for Nuclear Safety and Radiation Protection (ANVS), sent an OSART mission to Borssele in September 2014. The IAEA made 22 recommendations and eight suggestions for improving operational safety at the plant. The IAEA has completed the OSART follow-up mission in 2017. (WNN 2017)

In 2023 (23 January – 9 February) again an IAEA OSART mission took place. The team identified 11 issues, three of them are recommendations, and eight of them are suggestions. Among them, there was a very safety relevant issue concerning ageing effects and maintaining program (IAEA 2023):

4.2(1) Issue: The plant's corrosion protection and inspection programmes are not sufficiently robust to monitor safety and non-safety related systems, structures and components (SSCs) and to timely address its deficiencies to ensure the safe operation.

During the review the team noted a lot of corrosion on safety related systems, for example:

- Corrosion on valves of essential cooling water system.
- Heavily corroded bolts, nuts flanges on emergency feed water back up system (RS – system), bunkered safety related equipment.
- Heavily corroded strut of essential cooling water system with a defect tag.

They noticed also corrosion on non-safety related systems like corrosion of valve for the steam generator blowdown system.

Furthermore, they find also shortcoming in the plant requirements, procedures and expectations:

- Risks and effects of corrosion on SSCs were not always taken into account during work planning, and resolution of defects were not always prioritized commensurate with the potential risk of SSC failure.
- In the system health report for the component cooling water system (safety related system) corrosion effects were mentioned. The work request has been approved, but no corrective actions have been taken.
- In the last five years, 70 work requests regarding corrosion have been made, eight work requests were in the status 'Approved' (working orders have not been issued), 10 work requests were in progress.

The IAEA OSART Team concluded: *Without appropriate response and implementation of corrective actions, corrosion could affect safety and non-safety related systems, structures and components and jeopardize the safe operation of the plant.*

Thus, the IAEA OSART Team suggested: *The plant should consider enhancing its corrosion protection and inspection programmes to ensure timely identification, monitoring and correcting of deficiencies on safety and non-safety related SSC, whose failure could jeopardize the safe operation of the plant due to corrosion effects.*

The plant has developed a programme of system health for monitoring, control and analysis of the plant status and performance for maintaining the safety and reliability of the plant. However, the IAEA OSART Team noticed the following issue:

5.1(1) Issue: "*The plants System Health Monitoring Programme and Obsolescence programme are not sufficiently robust and prioritised to ensure that risk of degradation of the plant systems, structures and components is minimised.*"

There were a lot of shortfalls in the plant's System Health Monitoring programme, among others:

- Out of 21 systems identified to be important for safety and reliability only three of those 21 systems had an updated System Health Reports (SHR) during 2022.
- The plant had an expectation to update SHR important for safety every 12 months. However, in 2021 only 13 SHR were updated out of 21, in 2020 only five SHR were updated, in 2019 only 16 SHR were updated.
- In 2016 it was identified that a centrifugal pump had a vibration pattern that could affect the pump's ability to fulfil its function when needed. This was further emphasized in a system health activity for fire suppression system in 2018 and 2019, despite this, the actions were still open.
- 58 actions from SHR were open; 29 of these 58 actions did not have an update of the status as requested by the plant requirements and there was no regular check of actions from SHR every third month as required by plant expectation.
- The number of plant status deviations was 47, which exceeded the plant target of 30. Of the 47 plant status deviations, 10 were related to nuclear safety.

Furthermore, there were shortfalls in the plant obsolescence process:

- During the outage of 2021, a temperature transmitter was outside its acceptance criteria and had to be replaced. The original component was obsolete, and the replacement component had not been identified in advance or qualified for the specific application and that had to be done before the installation.
- An isolation barrier module had to be replaced. The component was obsolete, and the proposed replacement component had not been identified in advance or qualified for the specific application.
- The register for identifying obsolescence components was under development and contained 82 components of which 60 were not prioritized.

The IAEA OSART team concluded: *"Without a structured, systematic and prioritized arrangements for system health monitoring and obsolescence there is a risk of degradation of systems, structures and components jeopardizing the plant safety and reliability."*

They suggested: "*The plant should consider strengthening its programmes for System Health Monitoring and Obsolescence to ensure that they are robust and prioritised to ensure that the potential risk of degradation of the plant systems and components is minimised*."

The results of the OSART mission contradict the statements of the EIA REPORT (2024) that the ageing management effectively prevents physical ageing as well as technological ageing (obsolescence).

Reactor Pressure Vessel (RPV)

In 2012, a new type of in-service inspection (ISI) of the reactor pressure vessel (RPV) by ultrasonic testing (UT) was introduced in Belgian nuclear power plants. Yet, in the RPV wall of Doel-3 and Tihange-2 these inspections find a large number of flaw indications, located at different distances from the surface in the lower and upper vessel forged rings. As this technique is not suitable to find any flaws far from and nearly parallel to the surface, additional UT with straight beam (0°) was applied. With this technique, thousands of nearly laminar indications were found at larger depths of the base metal. Following a number of investigations and evaluations, the UT indications in the RPV of Doel-3 and Tihange 2 were unambiguously assigned to hydrogen induced flaws. (WENRA 2017a)

In response to the findings in the Belgian reactors, WENRA recommended the nuclear safety authorities in Europe to request the licensees to verify the material quality and integrity of the RPV in a 2-step approach (WENRA 2017a):

- A comprehensive review of the manufacturing and inspection records of the forgings of the RPV
- Examination of the base material of the vessels if considered necessary.

Furthermore, it may be considered by the national regulators to extend the scope of analysis to large forgings of other primary equipment.

In 2013, more than 40% of the RPV surface of the Borssele NPP was inspected by the qualified multiple UT straight beam techniques. The inspected area consisted of 4 vertical sectors, each 1m wide over the full accessible height of the RPV rings and the bottom shell. No reportable flaw indications were found. It was concluded that the hydrogen flaking phenomena is not present in the Borssele RPV. (WENRA 2017a)

In ANVS (2017a) it is stated that based on foreign experiences like Davis Besse, the hydrogen flakes in Doel/Tihange and the Carbon Segregation issue additional inspections/measurements were done, that showed that these issues are not impacting the RPV. Also recently, a modernized measurement was done to detect underclad cracks. None were found. ANVS concludes that this AMP is effective.

The most important ageing issue is the potential embrittlement of the material. The regulator's assessment and conclusions on ageing management of RPVs in the ANVS (2017a) explained that during the LTO-programme a complete ageing management review of all aspects was done, including the introduction in 2007 of test specimens in the available irradiation chambers. With the conservative assumption of 55 FPY produced electricity at 60 years of the life the calculated fluency is below the assumed value for the design in 1973. Taking into account the first specimen assessments after 7 years (2014) at 60% of the 55 FPY, the

RT-limit values are well below the norm, confirming a large margin. It is stated that in 2018, the specimens have reached 100% and again the effects will be assessed.

In the previous LTO-license, a set of specific LTO requirements was incorporated related to ageing management. It is stated: "*Except the final verification for the RPV integrity based on an assessment of the surveillance specimens, all the requirements are fulfilled. The verification for the RPV was finished in 2019*." (ANVS 2022a)

According to ANVS (2019b), the specimens reached more than 100% of the assessment fluence. It is concluded that after 60 years of operation margins are still available.

This assessment is to be considered insufficient to authorize a further extension of the operating period. It was already a request by the expert statement for the Scoping phase that due to the long operating life of the plant, evidence for safe continued operation, in particular for safety-relevant components such as the reactor pressure vessel, primary circuit pipes, steam generators, containment, etc., should be presented in the EIS. This evidence should also refer to the scenarios to be investigated in the EIA (10, 20 years or indefinite continued operation). (UMWELTBUNDESAMT 2023)

European stress test

End of 2012, the set of measures was consolidated in the National Action Plan (NAcP) of the Netherlands, which has been updated twice (2014 and 2017). The final NAcP was published in 2020. All 46 planned actions identified in the national stress test analysis and review of NPP Borssele have been completed by EPZ. (ANVS 2020a)

It is explained that after the 2011 Fukushima accident, numerous improvements have been implemented, for example: An external cooling system has been provided for the reactor vessel, which involves flooding the cavity between the reactor vessel and the concrete enclosure with water. External reactor vessel cooling can be necessary in extreme situations to ensure that a melting core remains contained within the reactor vessel. (see chapter 5)

Periodic Safety Reviews (PSRs)

In the Netherlands, since about 25 years one of the conditions of the licence of the Borssele NPP is that the safety of the nuclear installation is to be periodically reviewed in the light of operating experience and new safety insights. Since 2011, also the Euratom Directive on nuclear safety is applicable which contains a similar requirement, which was reinforced with the 2014 Amendment.

The PSR involves a review of the plant's design basis in the light of new developments in regulations, research, safety thinking, risk acceptance, etc. In 2011, the updated NVRs were implemented. According to ANVS (2019a), a new NVR on PSR came into force, based on the corresponding IAEA safety standard NS-G-

2.10. However, this IAEA Safety Guide, published in 2003, has been superseded by SSG-25, already published in 2013.

There have been three PSRs, called '10EVA': in 1993, 2003 and 2013. Throughout the years, the focus has moved from hardware-oriented modifications to more organisational modifications.

- The first PSR was followed by a major 200 million Euro modification programme, with increased functional and structural separation, protection against external events.
- The second PSR resulted in a fine-tuning of the safety concept of the plant rather than major changes.
- The third PSR at the end of 2013 had some interface with LTO-issues, but it was agreed by the ANVS and EPZ not to combine the two subjects of LTO and PSR but to execute two complementary projects, each having its own time frame. All identified safety-enhancing measures from 10EVA13 have been completed. There were 19 technical measures and four more organisational, personnel and administrative measures. This PSR also had some interfaces with the stress tests.

The results of the fourth PSR (2013-2022) are not mentioned in the EIA REPORT (2024). Nor is it explained whether the elimination of the weaknesses identified in the fourth PSR is a prerequisite for approval for a further lifetime extension. It was a request already by the expert statement of the Scoping phase that the EIS should present in detail the findings of the latest available PSR, which is a prerequisite to decide on the intended long term operation in general. However, it is only mentioned that the PSR is done, findings are not presented.

Legal requirements

In most countries, nuclear safety requirements are set in accordance with the international safety standards of the International Atomic Energy Agency (IAEA) and (within the EU) with the guidelines established by the Western European Nuclear Regulators Association (WENRA) and the European Nuclear Safety Regulators Group (ENSREG). However, the responsibility lies with the national regulatory authorities, and despite the efforts of the international organizations to harmonize these requirements, national differences remain, and the importance attached to different safety aspects is not necessarily consistent.

It was a request by the expert statement to the Scoping phase that the regulatory requirements for continued operation beyond 2033 should be described. The extent to which the regulations correspond to the current state of science and technology should also be described. (UMWELTBUNDESAMT 2023)

It was recommended by UMWELTBUNDESAMT (2023) that the EIS should describe the nuclear safety framework and its provisions, which are relevant to decide on the LTO. It should be presented how the recent updates of the regulations and the corresponding recommendations elaborated by international and Euratom institutions (IAEA, WENRA Safety Reference Levels, WANO) are implemented in the Dutch legal framework.

This is only done in a very general way. It is not specified which current IAEA documents or WENRA documents are applied and to what extent these are binding for a possible approval of an extension of the operation time.

WENRA Reference Level

In 2006, WENRA published reference levels for the first time as a safety standard for nuclear power plants in operation. In 2007 and 2008, 295 reference levels were updated. The accident at the Fukushima Dai-ichi nuclear power plant in March 2011 prompted WENRA to incorporate the lessons learned from the accident and to revise and expand the reference levels. The new guidelines were published in September 2014 in the report "WENRA Safety Reference Levels for Existing Reactors" (WENRA 2014). The report contains guidelines organized into 19 issues from the five safety areas of management, design, operation, inspection and emergency preparedness. In total, the 19 issues contain 342 safety guidelines.

Reference Level F has been completely revised and the concept of "Design Extension Conditions" (DEC) has been introduced. According to WENRA Reference Level F, all reasonably practicable measures should be implemented that can prevent severe accidents (DEC A). In addition, measures should be implemented to mitigate the possible effects of postulated severe accidents in the reactor core and the spent fuel pools and the resulting core meltdown phenomena (DEC B).

According to the ANVS (2020a), a major part of 2014 RLs was already part of the existing national regulations. In 2018, the remaining RLs were implemented as new licence conditions. However, according to WENRA (2023a), there is still a RL of issue F, which is not implemented in the Netherlands.

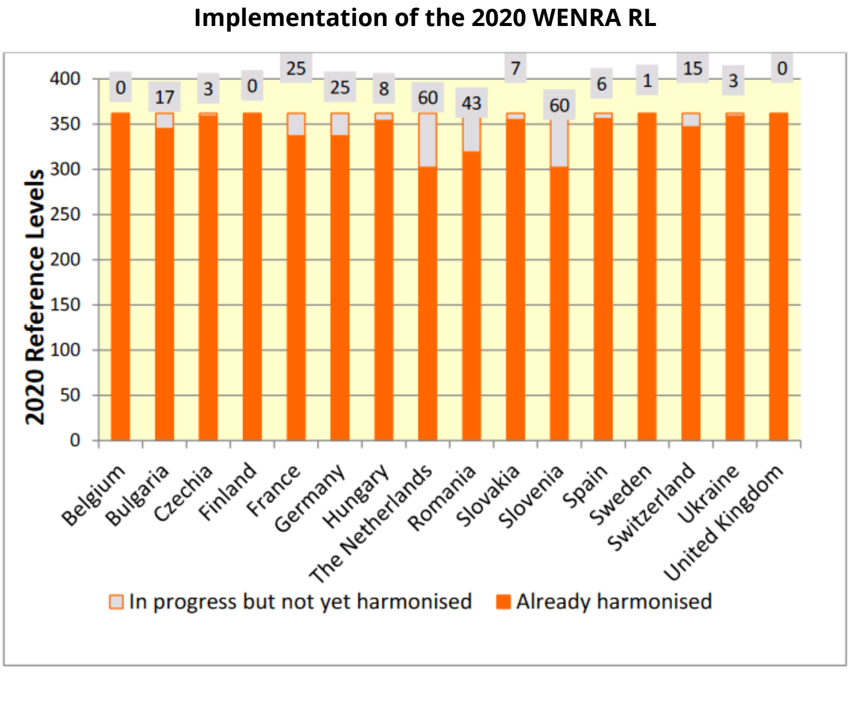
SRL F4.16: *There shall be an operational and habitable control room (or another suitably equipped location) available during DEC in order to manage such situations.*

WENRA (2023a) stated: This SRL is implemented in all participating countries with the exception of the Netherlands, where "partially" implemented is reported. In the Netherlands, this is because the operability and habitability of a control room during DEC is currently rediscussed in the 2023 PSR. The EIA REPORT (2024) does not mention the lack of guarantee of the operability and habitability of a control room during DEC.

In the meantime, the WENRA SRLs have been updated again. The 2020 version of the RLs, considers issues not revised in the 2014 version. (WENRA 2021) The 2020 RLs review identified the need to introduce the notion of leadership into Issue C (Leadership and Management for Safety) and obsolescence into Issue I (Ageing Management). There was also a need to complete the hazards to be addressed in the safety demonstration. To achieve this Issue S (Protection against Internal Fires) has been extended to cover all internal hazards (Issue SV), and Issue T (Natural Hazards) has been extended to address all external hazards (Issue TU). All other issues remain unchanged from the previous version. The 2020 version of the RLs consists of 19 issues with 362 RLs in total.

As of 1 January 2024, the preliminary status (regulatory side) reported by the WENRA countries is the following (WENRA 2024a):

Figure 2: Implementation of the 2020 WENRA RL Status 1 January 2024 (WENRA 2024a)



Source: WENRA 2024a

Figure 2 shows that the Netherlands 60 RL has not implemented yet. The implementation should be regarded as a prerequisite for a possible lifetime extension but should also be made mandatory in the procedure for amending the Atomic Energy Act. The safety of a plant can only ever be measured against the relevant regulations. Since there are no requirements for the important safety aspects such as ageing and protection against internal fires in the Dutch regulations in line with the state of the art, it cannot be guaranteed that the safety level of the plant corresponds to the current state of the art.

Coverage of recommendations formulated by UMWELTBUNDESAMT (2023)

Already in the expert statement to the Scoping phase, it was explained that from an Austrian point of view, accidents, which could lead to the release of radionuclides, mainly airborne, are of special interest. (UMWELTBUNDESAMT 2023) Therefore the EIA Report should present a plant description, mainly what safety relevant features are in place and/or intended to be implemented, to limit the possible release of radionuclides into the environment. It was recommended that related to the technical description of the plant, the EIS should include sufficient information on:

- Detailed description of active and passive safety systems, including in-formation regarding redundancy and diversity.
- Description of the containment and protective building structures (wall thickness etc.).

- Information on the implementation of the concept of defense-in-depth.
- Ageing Management Programme: special focus should be given to the intended lifetime extensions in Alternatives 1, 2 and 3.
- For each of the safety relevant components, mainly of the primary circuit, it should be described when and by which methodology it was assessed.
- Description of the safety relevant parts and the methodology and testings' to assess the lifetime of SSC.
- The plant description should also include information on those parts of the plant which, by technical reasons, cannot be assessed.
- For each of the intended alternatives necessary upgrades should be described.
- The EIS should allow to see how and to what extent safety margins for the proposed Alternatives 1, 2 and 3 will change.
- Some parts of the primary circuit cannot be replaced, like the reactor pressure vessel. Due to its age, results of the latest available PTS analysis and an elaboration of the used methods should be presented in the EIS.

Assessment: None of the issues of the above mentioned recommendation are provided in the EIA REPORT (2024).

4.3 Conclusions, questions and preliminary recommendations

The Borssele NPP, one of the oldest operating NPP in the world, started commercial operation in 1973. It is a 2-loop Pressurized Water Reactors (PWR) constructed by the German company Siemens/KWU. Four different constructions lines of the KWU PWR were developed and operated. The Borssele NPP belongs to construction line (CL) 1, both other reactors of this CL have been already shut down permanently in 2003, and 2005 respectively. Besides three younger reactors in Spain, Switzerland and Brasilia, all KWU reactors are shut down permanently. ANVS (2019a) considered the permanently shut down of all German KWU PWRs as a challenge. In 2022, a new Dutch TSO, a consortium of Bel-V, IRSN and bureau Veritas, was founded to guarantee support in the coming years.

From an Austrian point of view, accidents are of special interest. Therefore, the EIA Report should present a plant description including safety relevant features to limit the possible release of radionuclides into the environment. However, the technical design of the Borssele NPP is only described in a very general manner.

The original safety report of the Borssele NPP covered a 40-year operational lifetime, equating to the closure in 2013. However, in 2006, a political agreement ("Borssele Covenant") allows the operation to 2033 under certain conditions. One requirement is that the Borssele NPP belongs to the top 25% in safety of reactors in the EU, Canada and the USA. To assess whether Borssele NPP meets this requirement, the Borssele Benchmark Committee has been established. In its third report, the committee has selected important safety-related points of the design for comparative evaluation. (BBC 2023) However, other important design features are missing, such as the thickness of the reactor building.

Apart from the fact that the Commission's assessment is not very credible, especially in view of the results of the GRS safety review, a comparison with the safety level of new nuclear power plants should be made to assess the safety level of the Borssele nuclear power plant.

In 2008, the German TSO GRS developed a procedure for comparing the safe-ty of German NPPs of the different ages. The comparison showed that GKN-1, commissioned in 1976 (KWU CL 2) had a safety disadvantage in 17 of 23 assessment objects compared to GKN-2 (1989, KWU CL 4). Weaknesses were found at all levels of the defence-in-depth concept. The comparison also revealed that the average annual event rates at GKN-1 are significantly higher, in the area of events with ageing relevance, the number is four times higher.

The ageing management programme of the Borssele NPP has weaknesses as the results of the current IAEA OSART missions revealed. The results of the OSART mission contradict the statements of the EIA REPORT (2024) that the ageing management effectively prevents physical ageing as well as technological ageing (obsolescence).

The results of the fourth PSR (2013–2022) are not mentioned in the EIA REPORT (2024). Nor does it explain whether the remediation of the identified weaknesses is a prerequisite for the approval of a further lifetime extension.

The 1993 safety report included a statement that the plant design was based on a 40-year operating period. Following an LTO project, approval was grant-ed in 2013 for a lifetime extension. The LTO project was based on now-obsolete IAEA documents.

It was a request by the expert statement to the scoping phase that the regulatory requirements for continued operation beyond 2033 should be described. The extent to which the regulations correspond to the current state of science and technology should also be described. This is only done in a very general way. It is not specified which current IAEA or WENRA documents are applied and to what extent these are binding for a possible approval of an extension of the operation time.

The safety of a plant can only be evaluated against the relevant regulations. If there are no requirements for the important safety aspects such as ageing and protection against internal fires in the Dutch regulations in line with the state of the art, it cannot be guaranteed that the safety level of the plant corresponds to the current state of the art.

Questions:

Q10: *What are the results of the embrittlement of the reactor pressure vessels (RPVs) for the Borssele NPP? On the basis of which well-founded investigations are the safety margins considered sufficient and for which period of time?*

Q11: *Is there a systematic evaluation of the design deviations from the current international safety standards and requirements envisaged?*

Q12: *When will the WENRA 2020 RL be fully implemented in the Dutch regulations? Is the application of the RL binding for the possible lifetime extension of the Borssele NPP? When will a review be conducted if the RL will be met for the Borssele NPP?*

Q13: *Which WENRA Documents are mandatory for the lifetime extension? Which IAEA Documents are mandatory for the lifetime extension?*

Q14: *What experience has already been gained with the newly formed TSO? Is it equipped with sufficient resources to accomplish the challenging task?*

Q15: *In which systems it is not technically possible or is avoided for economic reasons to backfit physical separation of safety systems?*

Q16: *Which safety systems of different levels of the defense-in-depth concept are not independent of each other at the Borssele NPP?*

Q17: *What are the main findings of the fourth PSR? Which modernization measures and in which time frame are envisaged?*

Q18: *What technically feasible improvements to meet modern safety requirements were not considered "reasonably practicable" for the Borssele nuclear power plant as part of the fourth PSR?*

Preliminary recommendations

PR5: The EIS should describe the nuclear safety framework and its provisions, which are relevant to decide on the LTO. It should be presented how the recent updates of the regulations and the corresponding recommendations elaborated by international institutions (IAEA, WENRA Safety Reference Levels, WANO) and Euratom are implemented in the Dutch legal framework.

PR6: The EIS should present in detail the findings of the fourth PSR (2013-2022), which is a prerequisite to decide on the intended long term operation in general.

PR7: It is recommended that the remedy of the identified weaknesses of the fourth PSR have to be prerequisite for approval for a further lifetime extension.

PR8: The implementation of the 2020 WENRA RLs should be regarded as a prerequisite for a possible lifetime extension but should also be made mandatory in the procedure for amending the Atomic Energy Act.

PR9: Before the law is amended, it should be evaluated if the many corrosion events identified by the OSART team can be effectively counteracted or if physical and technical aging not only makes this difficult but even excludes it.

PR10: It is recommended to undertake a comparison of the design and measures of the Borssele NPP with all requirements of WENRA SRL F. In case of deviations will be found and accepted the reasons for this decision should be explained.

PR11: It is recommended to implement all technically available safety improvements to prevent accidents.

PR12: It is recommended provide the following further information:

- a detailed description of the safety systems, including information on requirements for the important safety-relevant systems and components. Furthermore, detailed description of the measures taken to control severe accidents or to mitigate their consequences.
- Information about the applied national requirements and international recommendations.
- comprehensible presentation and overall assessment of all deviations from the current state of the art in science and technology. This presentation should include:
  - All deviations from the modern requirements for redundancy, diversity and independence of the safety levels.
  - Incompleteness of the database and plant documentation used.
  - Presentation of all safety assessments or parameter definitions by personal expert assessments ("engineering judgement").
  - Presentation of the general dealing of uncertainties and nonknowledge and its effects on risk
  - Deviations from the state of the art in science and technology with regard to the detection methods used, the technical estimates and calculation procedures.
  - The safety margins available for the individual safety-relevant components and their respective ageing related changes compared to the original condition.
- Information to the ageing management programme, including
  - The very important safety issue of the ageing of the RPVs (embrittlement), including definition and justification of appropriate safety margins.
  - Evaluation of the conditions of the RPV internals and head penetrations including trends of events, and envisaged exchange measures.
  - Evaluation of the conditions of components of the primary circuit components and of the electrical installations including trends of events, and envisaged exchange measures.
- Regarding operation experience, the EIA documents should present an evaluation of safety relevant events including the lessons learned.

5 ACCIDENT ANALYSIS

5.1 Treatment in the EIA documents

Chapter 8 of EIA REPORT (2024) deals with nuclear safety. In the introduction it is explained that the safety level of a nuclear installation is determined by the safety requirements on which its design, and any later design improvements, are based (the design basis) and its mode of operation. In practice, this means demonstrating, using deterministic and probabilistic analyses, that the design of the plant safeguards nuclear safety functions. It also means demonstrating, based on radiological analyses, that the consequences for the environment of potential accident scenarios are controlled.

In section 8.2.1 safety objectives and functions are described. In order to meet the objectives, the following three safety functions must be fully met:

- The control of the reactivity.
- The removal of heat from the reactor and nuclear fuel storage.
- The isolation of radioactive materials.

Radiological requirements in postulated design basis accidents

It is stated that Article 18 of the Nuclear Facilities, Fissionable Materials and Ores Decree lays down several mandatory and potential grounds for refusing an application for a permit under Section 15(b) of the Nuclear Energy Act. The reasons for refusal in Article 18(2)(a) of the Decree concern the limits for postulated initiating events. Accidents that do not involve a core melt must have no or only a limited radiological impact on the environment. Dose limits are linked to the frequency with which accidents can occur without resulting in a core melt. The more likely an accident is, the lower the dose due to the accident may be. Table 8-3 of the EIA REPORT (2024) (see Table 1) gives the legal dose limits for events as stipulated in the Decree (Article 18(2)).

Table 1: Event frequencies and dose limits for postulated accidents (EIA REPORT 2024)

Event frequency F per year	**Maximum permissible dose allowed per person**	
	Persons aged 16 years and over	Persons under the age of 16 years
F ≥ 10-1	0.1 mSv	0.04 mSv
10^{-1} > F ≥ 10^{-2}	1 mSv	0.4 mSv
10^{-2} > F ≥ 10^{-4}	10 mSv	4 mSv
F < 10^{-4}	100 mSv	40 mSv
Thyroid dose ≤500 mSv		

Chapter 8.4.1.1 discusses the managing of design basis accidents. For nuclear power plants, it has to be demonstrated that all possible accidents that could reasonably happen can be controlled and that the consequences, such as any

radioactive discharge, are within the legal criteria. These accidents can be triggered by internal events, such as an internal power outage or fire, and from external events, such as flooding or an earthquake. Accident analyses are used to demonstrate that the potential consequences of postulated initiating events (design basis accidents) are adequately controlled by the design. These accident analyses are generally divided into thermo-hydraulic analyses (the way the plant is behaving) and radiological analyses (consequences for the environment).

For thermal-hydraulic analyses, the reactor system is 'converted' into a computer model. A calculation is then done of how the plant will respond to the postulated initiating events. When deciding which representative initiating events would be analysed, a basic list was used based on the IAEA's international guidelines. Installation-specific characteristics were added to the list. Not all these initiating events have been analysed in detail; only the representative (covered) initiating events using the most stringent protection target of the covered initiating events. Where relevant, accident situations have been considered for non-power operations as well as for power operations.

Using thermal-hydraulic analyses, it is demonstrated that the plant can be brought into and maintained in a safe condition after all postulated initiating events and that the relevant safety objectives are safeguarded. These analyses and their results have been included in the Safety Report (EPZ, 2015) as it was used to obtain the permit for the Borssele nuclear power plant pursuant to the Nuclear Energy Act.

Some design basis accidents may result in discharges that may exceed the emissions from normal operations. Based on radiological analysis, it must be demonstrated that the effects of this kind discharge are below acceptable limits.

The amount of radioactivity discharged is determined, and a dispersion model is used to calculate how this activity spreads in the environment. Depending on the spread of radioactivity, the impact on people in the vicinity is calculated. First, the effective dose (E), being the measure of the effect of the total amount of radiation that the human body absorbs over a given period. Secondly, the thyroid dose (Hth), which refers specifically to the amount of radiation absorbed by the thyroid gland. The radiological analyses were conducted in accordance with guidelines in the Netherlands.

For the committed effective dose for children, a period of 70 years is applied, and for adults this period is 50 years.

The results of the thermo-hydraulic and radiological analyses were reported in the Safety Report (EPZ, 2015), as used to obtain the permit for the Borssele nuclear power plant pursuant to the Nuclear Energy Act. With these results, the Safety Report demonstrates that the relevant legal criteria are met for the design basis accidents under consideration (see Table 1).

Accidental discharges into surface water or sewers (contaminated water used to fight the fire) were only considered if they could contribute significantly to the risk.

Safety level 4

Section 8.3.2 of the EIA REPORT (2024) describes the permissible risk as a consequence of postulated beyond design basis accidents (Safety Level 4). The preconditions for safety level 4 require that core melt accidents that could lead to early and/or large-scale discharges are practically ruled out. The objective here is that, if a core melt accident occurs, only protective measures that are limited in time and scope need to be taken and that there is enough time to implement them. All reasonably possible solutions that can reduce the potential exposure of employees, the general public and the environment must be implemented.

In a core melt accident, the containment is the main barrier for protecting the environment from radioactive material. That is why it is essential to keep the containment intact. With this in mind, the plant has to be designed in such a way that any discharges during a core melt are kept to an absolute minimum. For this, the criteria as summarised in Table 8-4 of the EIA REPORT (2024) (see Table 2 must be met. The Nuclear Facilities, Fissionable Materials and Ores Decree (Article 18(3)) states that the risk analysis for the individual (site-specific) risk must demonstrate that the probability that a person, who is unprotected and permanently outside the site, dies as a result of an accident is less than 10^{-6} per year.

For the group risk, this risk analysis must demonstrate that the probability that a group of at least ten people present outside the facility in question will be direct fatalities of an accident, is less than 10^{-5} per year.

Table 2: Permissible risk for those living in the vicinity as a result of beyond design basis accidents (EIA REPORT 2024)

Type of risk	Permissible risk
Individual risk	≤ 10^{-6} per year
Group risk	–
10 casualities	≤ 10^{-5} per year
100 casualities	≤ 10^{-7} per year
1000 casualities	≤ 10^{-9} per year

Chapter 8.4.1.2 describes the managing of beyond design basis accidents. In addition, nuclear power plants are also obliged to demonstrate that the permissible risk to local residents from beyond design basis accidents meets the applicable criteria. To demonstrate this, it is customary at an international level to carry out a probabilistic safety analysis (PSA). The EPZ also conducts a similar PSA.

An investigation of this kind deals with accidents that could lead to damage (including a meltdown) of the reactor core as well as leakage or failure of the containment building. The scope includes events that, due to internal causes (such as component failure or human failure) or external influences (such as an earthquake or flood), could lead to a core melt. For these kinds of accidents, the consequences of radioactive discharges, which may occur in these accidents, are calculated.

- PSA Level 1: Determining the overall probability of severe damage or melting of the reactor core.
- PSA Level 2: Determining the pressure on the containment building and the possible loss of its function. In the process, the specific characteristics of the resulting accidental discharges are accurately determined.
- PSA Level 3: Based on the accident discharges determined in the Level 2 analysis, the radiological implications for humans and the environment are determined based on the dispersion and deposition of radioactive substances in the environment, in accordance with guidelines in the Netherlands of Level 3 PSA.

Safety Level 5

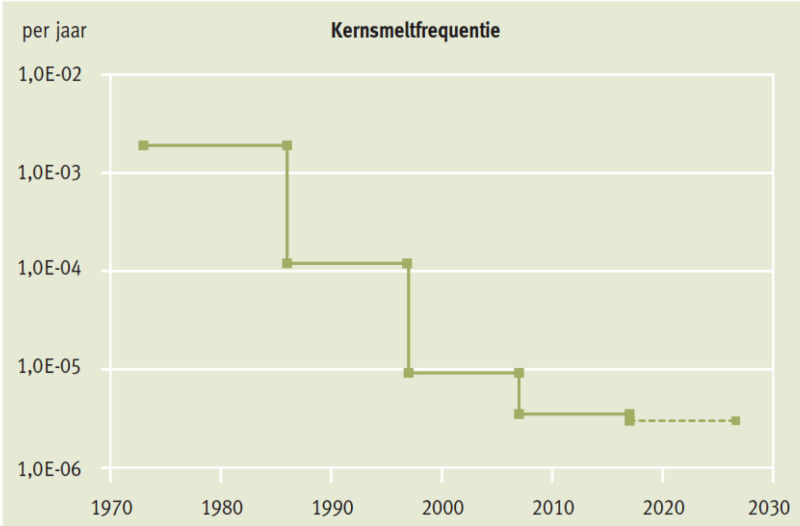
For the last (extremely unlikely) safety level, radiological effects may occur off-site that require protective measures. These kinds of measures may include iodine prophylaxis and sheltering or evacuating nearby residents within a given zone around the plant. Such measures are carried out under the guidance of the external emergency response organisation. Management of radiation accidents is organised at national and regional level in line with the National Radiation Crisis Plan. Because radiation accidents can cross borders, the European Union countries have agreed that the countries involved will alert and inform one another as soon as possible.

Core melt frequency (CDF)

With all the physical and organizational measures in place, the core melt frequency has been reduced by about 1,000 times over the past 40 years, as shown in Figure 3.

Figure 3: Trends in core melt frequency (EIA REPORT 2024)

Trends in core melt frequency



Source: EIA REPORT 2024

Individual risk

Individual risk is calculated by combining the risk of death due to short- and long-term effects. The individual risk is for the critical cohort (one-year-old children) determined as a function of the distance from the Borssele nuclear power plant. The assumption for this is that only the area outside the site boundary (which is at least 350 metres from the plant discharge point) is inhabited. In addition to this, the implementation of the legally required food measures were assumed when calculating individual risk.

The results of the PSA were reported in the Safety Report (EPZ, 2015), as used to obtain the permit from EPZ pursuant to the Nuclear Energy Act. In line with these results, the total maximum individual risk per year (for one-year-old children) of all source terms combined is presented in Figure 8-2 of the EIA REPORT (2024) as a function of the distance from the power plant. It is stated that applying the 'evacuation' countermeasures and 'iodine dispensing' in addition to food measures can reduce individual risk further. Figure 8-2 gives the results for the situation in 2015 and thereafter, after implementing safety-enhancing measures based on the third PSR (10EVA13) and the stress test.

Group risk

The group risk calculation assumes that immediate measures (such as evacuation and sheltering) are not implemented within 24 hours and that people in the contaminated areas are moved 24 hours after exposure. In addition to this, to calculate group risk, the implementation of the legally required food measures were assumed. It is shown that the group risk does not exceed the legal criterion for permissible group risk for any of the victims; instead it remains below the criterion by at least a factor of 10.

It is explained in EIA REPORT (2024) that for more details, please refer to the Safety Report (EPZ, 2015), accompanying the Borssele nuclear power plant's current permit under the Nuclear Energy Act, which describes the postulated events and the response from the plant and demonstrates that safety is ensured within the legal criteria.

5.2 Discussion

Severe Accident Management

During the first PSR, the Borssele NPP made a thorough study on the capabilities of the installation with respect to severe accidents. Based on this study both hardware and procedural measures were taken to expand its capabilities to prevent and mitigate the consequences of a severe accident. The hardware measures involved, amongst others, the installation of passive hydrogen recombinators (PARs), filtered pressure relieve of the containment and filtered air supply to the control room and a separate emergency control room. The procedural measures consisted of the introduction of an extensive set of symptom-based Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs). The EOPs are based on the Westinghouse Owners Group guidelines and consist of guidelines for the Emergency Support Centre, which initiates required actions, and procedures for the control room staff. These measures were implemented in 1994-1998. (ANVS 2019a)

As a result of the second PSR further measures have been implemented like improved extinguishing agents and capability to fight large kerosene fires, the implementation of automatic pressure relieve hatches to improve natural circulation inside the containment in order to prevent too high local hydrogen concentrations and the introduction of SAMGs for non-power conditions.

Amongst others the third PSR was used to verify how the NPP might comply with the new design requirements and guides introduced in 2011. In addition, the stress test has been carried out. Examples of further improvements that have been implemented until 2017 to prevent of mitigate beyond design basis accidents are:

- Increasing battery capacity on emergency grid 2
- Implementation of In Vessel Retention
- Several additional measures to refill and cool the spent fuel pool.

In-vessel molten core retention

An important safety improvement, which has the potential to strengthen the defense-in-depth, implemented in 2017, is the in-vessel molten core retention by creating a cooling opportunity of the outside of the reactor vessel. ANVS was looking closely at the development of ideas to stabilize the molten core after vessel melt-through in an existing reactor, using (part of) the functionalities of a core catcher in an adapted way.

In-vessel-retention (IVR) has been studied by the EPZ with the support of AREVA during the third PSR. The EPZ concluded that it is feasible to implement the IVR in the Borssele NPP. The ANVS requested GRS to review international experience with IVR to determine the important issues to look at and also to review the modification proposals. GRS undertook a number of verifications, amongst others its own verification calculations and concluded that the IVR should be possible. A modification application for a retrofit of an external cooling system for the reactor pressure vessel was filed by the EPZ and it was implemented in 2017. (ANVS 2019a)

The EIA Report (2024) only mentioned the IVR concepts. It does not explain whether the effectiveness has been sufficiently proven.

Safety Analysis

The Safety Report (SR) of the Borssele NPP is a document of little less than 700 pages. In this report a condensed representation is given of all safety related aspects regarding the installation and its surroundings. In addition to the Safety Report, the twenty-volume Safety Analysis Report (SAR), also known as the 'Technical Information Package' (TIP), provides extensive background information on all safety related aspects regarding the installation, plant layout and the safety analyses. The SAR also includes all details of the design base accident (DBA) analyses. The licence of Borssele NPP requires keeping the SAR/TIP up-to-date at all times. In parallel to the 3rd PSR, a new SR and SAR have been developed. It is explained that the SAR (TIP) is based on the recent set IAEA safety guides. (ANVS 2022a) However, it is not mentioned which IAEA documents are used.

According to ANVS (2022a), NVR-NS-R1 (Safety Requirements for Nuclear Power Plant Design) and NVR-SSG-2 (Deterministic Safety Analysis) state that a full range of events must be postulated in order to ensure that all credible events with potential for serious consequences and significant probability have been anticipated and can be accommodated by the design base of the plant.

However, as explained already in chapter 4, it is not clear if this requirement is based on current valid IAEA documents.

For the safety analysis of the Borssele NPP, the postulated initiating events (PIE) have been defined in the following categories according to their entrance probability (ANVS 2022a):

- Cat. 2 Design Basis Accidents (10-4 – 10-2/reactor year);
- Cat. 3 Beyond Design Basis Accidents (10-6 - 10-4/reactor year);
- Cat. 4 Severe Accidents (< 10^{-6}/reactor year).

In the updated safety report that was used for the modification license application in 2015, there is a basic list of 81 PIEs from the original design and an additional list of 59 PIEs. The additional list gives also more attention to events for the spent fuel pool (14 out of 59).

In the category 3 (beyond design) two representative cases of ATWS are added: emergency power and ATWS and total loss of main feedwater and ATWS. All other PIEs of this category are considered manageable with the existing provisions and additional measures taken, for instance based on the stress test and PSR. (ANVS 2022a)

Furthermore, it is stated that in category 4 (severe accidents) the probabilistic safety analysis is used.

It was already mentioned in UMWELTBUNDESAMT (2023) that the accident analyses should be carried out and described in such a way that it can be verified whether or to what extent accidents could lead to releases of radionuclides that could contaminate the territory of Austria. Accident analysis - design base accidents as well as beyond design base accidents - should be presented in the EIS. The accident analysis should be presented in detail to be able to evaluate if the intended long-term operation of the plant could pose a risk to even countries like Austria. However, this information is not provided in the EIA REPORT (2024).

The related accident analysis should be based on a deterministic approach.

Probabilistic safety analysis (PSA)

To quantify the risk of reactors, an analysis of the core damage frequency (CDF) is often used. This is determined in the context of probabilistic safety analysis (PSA). Central elements of a PSA are event sequence analyses. For this purpose, event trees are created for all events considered that could trigger an accident. These are intended to capture every possible subsequent development after the triggering event.

However, the determined frequency of a severe accident is subject to considerable uncertainties. Only some of these uncertainties can be quantified. In addition, there are uncertainties that were not quantified in the PSA or that generally cannot be quantified, such as complex human error, unexpected failures due to aging, unexpected events (e.g. extreme weather events), terrorist attacks and sabotage, or inadequate safety culture. (GP 2012)

Another potential uncertainty in the PSA and thus in the CDF is illustrated by the so-called “bathtub curve”. This is a representation of the different failure rates in an ageing process. In the first phase, the failure rate is still high due to early failures at the beginning of the lifetime. In the second phase, the failure rate of the component remains constant over a long period of time, and random failures occur. In the last phase, the effects of aging increasingly come into play and the failure rate rises again. In a “living PSA” each individual component would have to be assessed according to how old it currently is and what failure rate results from this. However, in most cases, for the sake of simplicity, the second phase (random failures) is used as the basis for the calculation. This means that the failure rate can be classified as too low, which in turn leads to an underestimation of the core damage frequency.

The calculated frequency of core meltdown accidents and of accidents with very high and early releases should therefore only be understood as a rough risk indicator and not as reliable information on the actual probability of such accidents. In principle, the actual probability cannot be determined. However, it must be assumed that it is significantly higher than the expected value calculated in the PSA. (GP 2012)

Core damage frequencies are not easily comparable because the scope of the analyses can vary from plant to plant, even in the same country. In addition, there are the inherent uncertainties of the method.

In general, it can be said that backfitting measures can have a positive effect on safety, especially if they address known weaknesses as effectively as possible. (INRAG 2021)

Probabilistic Safety Analyses for the Borssele NPP

After the PSA of Borssele NPP relating to the 1994 modification project had been completed, the focus shifted towards Living PSA (LPSA) applications. The licence of 1994 for the modified Borssele plant requires an operational Living PSA. Currently, the PSA for the Borssele NPP is updated yearly. This means that both plant modifications and updated failure data are included in the PSA model. In 1993, the first PSR took place. The PSR resulted in a major modification programme. The established modifications reduced the CDF from 5.6 10^{-5}/year to 2.8 10^{-6}/year. (ANVS 2022a)

The back-fitting measures have improved the safety of the Borssele NPP and reduced the risk of accidents. This can be seen from the PSA results, where the frequency of core damage has been significantly reduced (see Figure 3).

However, information on the contribution of different plant states and types of initiative events are missing. Also, the uncertainty of the PSA results are not provided (e.g. 95%-fractile).

Even though the reduction in core melt frequency is significant, the CDF is high compared to new NPPs. The CDF for new NPPs is lower by a factor of 10 to 100.

According to the EIA REPORT (2024), PSA 2 has also been carried out for the Borssele NPP. The EIA documents do not contain any information on the results of PSA 2, i.e. data on the frequencies for large releases (LRF) and large early frequencies (LERF) are not available. The results for large and/or early releases are of particular interest for assessing the risks for Austria.

Probabilistic analyses (PSA) should generally only be used to supplement deterministic considerations as criteria for sufficient safety. This is because only uncertainties in the input parameters that are covered by probability distributions can be quantified. Uncertainties arising from incomplete data cannot be quantified.

The provided EIA documents give some information about Design Basis Accidents including the scenarios, the releases and the consequences. However, the information about beyond design basis accidents and the severe accidents is very limited. Neither the scenarios nor the possible source terms are provided.

The "Safety Objectives for New Power Reactors" published by the reactor harmonization working group (RHWG) of WENRA can be seen as state of the art. These safety objectives, formulated in a qualitative manner to drive design enhancements for new plants, should be also "used as a reference for identifying reasonably practicable safety improvements for 'existing plants in case of periodic safety reviews". (WENRA 2013)

The most ambitious safety objective is to reduce potential radioactive releases to the environment from accidents with core melt. (Safety objective O3) Accidents with core melt which would lead to early releases without enough time to implement off-site emergency measures or large releases which would require protective measures for the public that could not be limited in area or time have to be practically eliminated. Even if the probability of an accident sequence is very low, any additional reasonably practicable design features, operational measures or accident management procedures to lower the risk further should be implemented. (WENRA 2013)

Although a continuous effort to increase the scope of the severe accidents that have been taken into consideration and to reduce their off-site consequences was undertaken, a further reduction of the potential radiological consequences should be an important goal for the Borssele NPP. In that context, the concept of "practical elimination" of early or large releases should be used. Occurrence of certain severe accident conditions can be considered as practically eliminated *"if it is physically impossible for the conditions to occur or if the conditions can be considered with a high degree of confidence to be extremely unlikely to arise"*. The concept of "extremely unlikely with a high degree of confidence" constitutes an essential element of the concept of "practical elimination", as defined by the IAEA. The demonstration that an accident is extremely unlikely with a high degree of confidence should take account of the assessed frequency of the condition and of the degree of confidence in the assessed frequency. Although this concept is only to be applied to new reactors, it should also be used for the Borssele nuclear power plant in order to reduce the existing risks. The demonstration should not be claimed solely based on compliance with a general cut-off probabilistic value.

Although probabilistic targets can be set, 'practical elimination' cannot be demonstrated by showing compliance with a general probabilistic value. No probabilistic value can be accepted as a justification for not implementing reasonable design or operational measures. The "practical elimination" can be demonstrated by deterministic and/or probabilistic considerations, taking into account the uncertainties due to the limited knowledge of some physical phenomena. The low probability of occurrence of an accident with core melt is not a reason for not protecting the containment against the conditions generated by such accident.

ANVS (2022a) described the use of PSA source terms for emergency planning & preparedness. It is explained that in the unlikely event that a severe event occurs at the plant with a serious threat for an off-site emergency, the 16 defined source terms in the PSA of Borssele are used as input for the prognosis. These source terms are already included as default input data in the computer codes being used for forecasting the consequences.

For the definition of the planning zones for evacuation, iodine prophylaxis and sheltering, originally the PWR-5 source term from WASH-1400 (Rasmussen Study) was taken as a conservative reference source term. Because the dose criteria for evacuation, iodine prophylaxis and sheltering were lowered, a re-evaluation of the reference source term was performed by the ANVS. Doing nothing would have resulted in (emergency) planning zones becoming significantly larger than before and larger than actually needed. It is explained in ANVS (2022a) that a more realistic source term was developed, tailored to the characteristics of Borssele NPP, matching the existing planning zone.

This approach is not appropriate from a safety perspective. It is not the source term that should be changed, but the emergency zones.

Source terms

According to ANVS (2019a), PSA Level 2 demonstrated that Steam Generator Tube Rupture (SGTR) events with a dry secondary side of the SG could cause the largest source terms and thereby, be a large contributor to the public health risk (Source Terms up to 50% Cs and I). The most promising strategy was the scrubbing of the source term through the water inventory in the SGs. By installing extra pathways to keep the SGs filled with water (including flexible hose connection with the fire-fighting system) a factor 14 reduction in the magnitude of the source term (CsI and CsOH) could be achieved.

The reduction of the source term of radiologically relevant radionuclides by a factor of 14 means still a release of 3.6% of the core inventory, which is still quite high. It is also not explained that the above mentioned measure could fail. Since the release scenario of a SGTR event with a dry secondary side of the SG cannot be practically excluded, a release of 50% of the Cs and I core inventory cannot be excluded.

Results of PSA Level 2, published in NEA (2007), show that: early releases account for 1.5% of total release frequency, with induced failure of SG tubes contributing to 60% of these cases. Leakage of the containment occurs in 30% of these cases. Containment rupture in the early phase is dominated by external events, which fail containment directly and account for 5 % of the early releases.

According to the EIA REPORT (2024), beyond design basis accidents (BDBAs) are considered. However, no further information is provided. The source term of a beyond design basis accident to calculate the possible consequences was not given in the provided EIA documents.

Even though the probability of severe accidents with an early and/or large release for existing plants is estimated to be very small, the consequences caused by these accidents are very large. The accident analyses in the EIA Report should use a possible source term derived by the calculation of the current probabilistic safety analysis 2 (PSA 2).

Coverage of recommendations formulated by UMWELTBUNDESAMT (2023)

In the following section, it is assessed if the recommendations of the expert statement to the scoping phase are fulfilled:

- The requirements for the safety systems should be described in detail; the requirements regarding the proof of the functioning of the provisions for preventing containment breaching and major releases should be presented. This should inter alia contain a section dedicated to the status of the embrittlement of the RPV.

Assessment: None of the aspects of this recommendation is fulfilled. Although it is mentioned that an ex-vessel cooling of the RPV is installed, no details are given about the technical realization or about the proof of its functionality. Information on the status of reactor pressure vessel embrittlement is also not provided.

- Descriptions of technical concepts for the prevention of large releases following a core-melt accident should be presented in the EIS.

Assessment: This recommendation is not followed. The technical concept for the prevention of large releases is only mentioned partly but not described.

- The EIS should describe how it is or will be assured that no meltdown can occur in the basement in the event of a core meltdown.

Assessment: The recommendation is not followed. The issue of core-melt through the basement in the event of a core meltdown is not mentioned at all.

- The EIS should present the ability of the plant to prevent major releases following a core meltdown and how this is or will be assured.

Assessment: The recommendation is only partly followed. The EIA REPORT (2024) only mentioned the IVR concepts. It does not explain whether the effectiveness has been sufficiently proven.

- The Core damage frequency of PSA results should be presented in detail (contribution of different plant states and types of initiators). An indication of the uncertainty of the PSA results should be provided (e.g. 95%-fractile).

Assessment: The recommendation is only party followed. The core damage frequency (CDF) is only illustrated in a figure. Neither details about the different contributions nor about uncertainties are provided.

5.3 Conclusions, questions and preliminary recommendations

It was already mentioned in UMWELTBUNDESAMT (2023) that the accident analyses should be carried out and described in such a way that it can be verified whether or to what extent accidents could lead to releases of radionuclides that could contaminate the territory of Austria. However, this is not at all the case.

The provided EIA documents give some information about Design Basis Accidents (DBA). The information about Beyond Design Basis Accidents (BDBA), however, is very limited. Neither the accident scenarios nor the possible source terms are provided. According to the EIA REPORT (2024), the calculated core damage frequency has decreased due to backfitting. Information on frequencies for large releases (LRF) is not provided.

The accident analyses in the EIA documents should use a possible source term derived from the calculation of the current probabilistic safety analyses 2 (PSA 2). Even though the calculated probability of severe accidents with a large release is very low, the consequences caused by these accidents are potentially enormous.

Core-melt accidents can cause a failure of the containment. These scenarios are associated with large releases. In 2017, an in-vessel molten core retention by creating a cooling opportunity of the outside of the reactor vessel is implemented. This could be an important safety improvement. However, the EIA Report (2024) only mentioned the IVR concepts without providing further details.

To assess the consequences of BDBAs, it is necessary to analyze a range of severe accidents, including those involving containment failure and containment bypass. Such severe accidents are possible for the Borssele NPP. A systematic analysis of BDBAs is missing in the provided EIA documents. In ANVS (2022a), it is stated that for severe accidents the probabilistic safety analysis is used. Based on the available information, it is not clear if accidents with a probability of less than 10^{-6} per year are considered.

According to ANVS (2019a), the PSA Level 2 demonstrated that Steam Generator Tube Rupture (SGTR) events with a dry secondary side of the SG could cause the largest source terms (up to 50% Cs and I). By a backfitting measure the possible source term could only be reduced by a factor of 14. Furthermore, since the release scenario of a SGTR event cannot be practically excluded, a release of 50% of the Cs and I core inventory are possible. Results of PSA Level 2, published in NEA (2007), show that: early releases account for 1.5% of total release frequency, with failure of SG tubes contributing to 60% of these cases.

When the WENRA RLs were updated in 2020, the hazards to be addressed in the safety cases were expanded on the basis of more recent experience and knowledge. Until all potential initiating events have been adequately considered, neither the accident scenarios nor the CDF values determined are sufficiently substantiated.

It is state of the art to use the WENRA "Safety Objectives for New Power Reactors" as a reference for identifying reasonably practicable safety improvements during a LTO project. According to the WENRA safety objective core melt accidents which would lead to early or large releases would have to be practically eliminated. Even if the probability of an accident sequence is very low any additional reasonably practicable design features, operational measures or accident management procedures to lower the risk further should be implemented for the Borssele NPP.

Questions:

Q19: *What are the source terms of the possible BDBAs calculated in the probabilistic safety analyses 2 (PSA 2) including releases from the spent fuel pools?*

Q20: *What is the source term and the accident scenario of the BDBA that is chosen to calculate possible trans-boundary consequences? What is the technical justification for the use of this BDBA?*

Q21: *Which design basis accidents can develop into a beyond design basis accident?*

Q22: *Which accidents scenarios with the loss of containment integrity or containment bypass are physically possible?*

Q23: *How could a melt-through of the basement due to a core meltdown accident be reliably prevented?*

Q24: *Has a DEC-B analysis been performed to identify reasonably practicable measures to mitigate the consequences of significant fuel damage or conditions that could lead to early or large radioactive releases, unless such damage or conditions have been determined to be extremely unlikely with a high degree of confidence?*

Q25: *Are target values for the probability of design basis accidents, design extension conditions (DEC) without significant core damage (DEC-A) and with core melt (DEC-B) specified in the Dutch regulations? What are the respective values for the Borssele NPP? Were deterministic analyses also carried out in each case?*

Q26: *When will an analysis of internal events be carried out in accordance with WENRA RL SV (WENRA 2021)? Did these safety cases already form part of the fourth PSR?*

Q27: *What is the technical design of the IVR concept? What studies have been carried out on its reliability and with which results?*

Preliminary recommendations

PR13: Based on 2014/87/Euratom Article 8a existing nuclear installations should reach a safety level as close as possible to new nuclear power plants. The approach to be in line with 2014/87/Euratom should be presented the EIA Report. The EIA Report should describe the differences between Borssele NPP - for each of the Alternatives 1, 2 and 3, in comparison to new nuclear power plants, with respect to the exclusion of early and large releases. This should include a description of releases of nuclides under design base and beyond design base accidents in comparison to new nuclear power plants. (See also UMWELTBUNDESAMT 2023)

PR14: It is recommended to use the WENRA Safety Objectives for new NPP to identify reasonably practicable safety improvements for the Borssele NPP. It is recommended to use the concept of practical elimination for this approach.

PR15: It is recommended to provide the following information concerning accident analyses and the results of the PSA (Level 1, 2 und 3):

- Core damage frequency (CDF) and large (early) releases frequency (L(E)RF)
- Contribution of internal events as well as internal and external hazards to CDF and L(E)RF
- List of the beyond design basis accidents (BDBAs) and severe accidents
- Source terms of all possible BDBAs and sever accidents
- Time spans to restore the safety functions after the loss of heat removal and/or station-blackout and cliff edge effects.

6 EXTERNAL HAZARDS

6.1 Treatment in the EIA documents

EIA REPORT (2024) explains that the current Phase 1 of the Environmental Impact Assessment (EIA) solely addresses eliminating legal obstacles to ANVS considering a potential permit application from EPZ for the extension of operations of the Borssele NPP. Only in a second step after amending the Nuclear Energy Act, the operator of Borssele NPP will have to demonstrate that the plant can continue to comply with all the relevant requirements which apply in the Netherlands in the long term, including international standards (Phase 2 of the EIA). EIA REPORT (2024) further clarifies that the decision as to whether the NPP will stay operational beyond 2033 will not be based on the EIA Phase 1. Phase 1 is concerned with describing the environmental impacts of the existing situation, extrapolating them beyond 2033 where possible and drawing up an agenda listing environmental focal points that require attention in Phase 2. A comprehensive treatment of external hazards and their effect on nuclear safety beyond a few listed hazards (see below) is consequently not I the scope of the available Dutch documents for EIA Phase 1.

With respect to the current state of nuclear safety and potential impacts of natural events in general, EIA REPORT (2024, p. 108) refers to “Safety Levels” of a “layered safety concept”, which is identical with the defence-in-depth (DiD) concept of WENRA (2013). Within this framework only events corresponding to Safety Level 5 are relevant to Austria. Level 5 equals DiD Level 5. By definition this level refers to significant releases of radioactive material leading to radiological off-site consequences requiring protective measures. Radiological consequences corresponding to Safety Level / DiD Level 5 typically result from core melt accidents (core damage; Safety Level / DiD Level 4). The current status of safety expressed by the Core Damage Frequency (CDF) obtained from Probabilistic Safety Assessment (PSA) for Borssele is summarized in Fig. 8-4 of the EIA REPORT 2024. Information on the contents (e.g., the types of events and hazards considered in the analysis) and methodology of the PSA are not available. The graph indicates that the CDF was stepwise reduced from an original value $>10^{-3}$ in the 1970ties (when Borssele NPP became operational) to a current value between 10^{-5} and 10^{-6}. Safety increased in time steps of around ten years. This suggests to the authors of the current report that decreases of the CDF were obtained through measures related to the periodic safety reviews since the 1970ties. The contribution of external hazards to the total CDF is not specified. It may, hover, be concluded that those individual external hazards that were considered in PSA contribute about 10^{-6} to the CDF or less.

External hazards considered in the EIA documents

With respect to natural hazards the focal points defined in EIA Phase 1 for Phase 2 only pertain to the effects of climate change on external flooding and some meteorological hazards:

- Sea level rise, in connection with the risk of external flooding.
- The increase in maximum seawater temperature, in connection with reactor cooling.
- The increase in maximum air temperature, in connection with the cooling of safety-related areas and systems.
- Increases of extreme weather events, such as more severe storms.

External flooding. EIA REPORT GERMAN SUMMARY (2024) states that, for the current situation, it has been proven that the Borssele NPP is adequately protected from external flooding by high sea water levels. In the event of a longer period of operation after 2033, these aspects must be proven again for the maximum possible water levels to be assumed at that point in time. EIA REPORT (2024) quantifies the expected rise in sea levels for the North Sea coast and the Western Scheldt with 16 to 38 cm and 20 to 30 cm compared to 2020, respectively. Such a rise in sea levels is not expected to challenge nuclear safety due to significant existing safety margins (EIA REPORT 2024, p. 123). EIA REPORT GERMAN SUMMARY (2024) still states that EIA Phase 2 will require proof that the NPP is adequately protected against the expected maximum sea levels in order to ensure nuclear safety.

Other external flooding hazards such as heavy rain, flash floods or water spout, which may also change due to climate change, are not addressed in the Dutch documents.

High water and air temperature: Borssele NPP takes cooling water from and discharges heated water into the Western Scheldt. The increase in average temperature due to climate change is expected to lead to an increase of the maximum water temperature of the ultimate heat sink. For the current situation, it has been demonstrated that the cooling systems can perform adequately at the maximum possible water temperature. For LTO, this will have to be demonstrated as part of the safety analyses of the maximum water temperature that may then occur. A similar situation applies to the ambient air temperature and its effect on air cooling in safety-related buildings (EIA REPORT GERMAN SUMMARY 2024). EIA phase 2 for LTO beyond 2033 will require poofs that the safety-relevant cooling systems can provide sufficient cooling even in accident situations in the event of the maximum water / air temperatures.

Low groundwater levels: Groundwater is used for emergency cooling. Due to climate change and increasingly dry summers falling groundwater levels may be expected. This may lead to possible restrictions on the extraction of groundwater and limit the availability of the emergency cooling water system.

High winds: EIA REPORT (2024, p. 123) regards possible increases in maximum wind loads and the potential for hurricanes due to climate change as particularly relevant. The safety-related buildings at the Borssele nuclear power plant are designed for wind loads of up to 125 m/s. This is regarded an ample safety margin against potential storms. EIA REPORT (2024), however, further informs that for LTO safety will have to be demonstrated for the maximum wind speeds postulated at that time. The results of this demonstration are to be included in EIA Phase 2.

Requirements and guidelines applicable to the EIA and LTO process

With respect to national legal requirements and international guidelines applicable in the EIA and LTO process, EIA REPORT (2024) states that the NPP will have to demonstrate that the plant can continue to comply with all relevant Dutch requirements and international standards in the long term in Phase 2 of the EIA. The LTO decision will be made on the basis of regulations which will be in place at the time of the decision. The current legal and policy frameworks for nuclear safety is outlined in table 8-2 of EIA REPORT (2024). This table refers to national legislation and IAEA guidance, notably without listing WENRA documents, most importantly the Safety Reference Levels for Existing Reactors. The latter are regarded to be of major importance for deciding about LTO (see below).

6.2 Discussion

External hazards to be considered in the EIA and LTO process

The Dutch EIA documents for Phase 1 of the EIA sets a focus on natural hazards that are expected to change (and generally increase) due to climate change in the decades after 2033, i.e., in the time envisaged for LTO of the Borssele NPP. Documents therefore only cover a very limited number of natural hazards such as external flooding caused by high sea water levels and some meteorological phenomena. No indication is made as how other hazards that apply to the Borssele site are to be treated in Phase 2 of the EIA and the LTO process.

Among the hazards not considered in EIA Phase 1 earthquake (vibratory ground motion) and the causally linked seismotectonic hazards liquefaction and dynamic compaction appear to be particularly relevant. The EU Stress Tests noted that the original design of the plant, which started operation in 1973, does not consider seismic loads (ENSREG 2012). Seismic hazard assessments performed in 1993 and updated in 1995 revealed a Design Basis Earthquake (DBE) with a

Peak Ground Acceleration (PGA)=0.06g[3]. This value is below the minimum value of 0.1g proposed for the seismic design of NPPs by IAEA (2010). It was further found that the cited DBE value for Borssele was significantly lower than that for the Belgian NPP Doel which is located about 35km east-south-east of Borssele. For Doel, ground accelerations of PGA=0.146g for a recurrence interval of 10.000 years (corresponding to the DBE) and PGA=0.053g for a recurrence interval of 1.000 years were communicated at the time of the Stress Tests, respectively. Comparison of the PGA values obtained for Borssele and Doel consequently indicated that seismic hazard was underestimated for the Borssele site: the DBE value for Borssele, PGA=0.06g, which should be valid for a recurrence interval of 10.000 years, is almost identical to the PGA=0.053g of the 1.000 years earthquake determined for the Doel site (note that WENRA, 2021, requires to define the DBE with an exceedance frequency, not higher than 10^{-4} per annum). The Netherland's National Action Plans following the EU Stress Tests consequently announced re-evaluations of seismic hazards and seismic safety (MINISTRY OF INFRASTRUCURE AND WATER MANAGEMENT 2017). However, data on the outcome of these investigations were not communicated in the framework of the National Action Plan (MINISTRY OF INFRASTRUCURE AND WATER MANAGEMENT 2021).

The identified discrepancies between the vibratory ground motion hazard identified for the closely spaced sites of Borssele and Doel and potential threats by soil liquefaction and dynamic compaction require that these threats be given particular attention in the upcoming Phase 2 of the EIA and LTO process.

Requirements and guidelines applicable to the EIA and LTO process

Available documents on Phase 1 of the EIA do not provide information on the general process that will be followed up in Phase 2 and in the final decision on LTO. It is unclear if revisions of the hazard assessments for all external hazards that apply to the site, re-assessments of the design bases for external hazards and adequate DEC assessments shall be part of the future LTO process and Phase 2 of the EIA.

In European countries like f.e. France, LTO is typically linked to Periodic Safety Reviews (PSR) and the achievement of pre-defined safety goals. WENRA (2021, Issue P, Periodic Safety Review) provides, on a high level, definitions of the scope and content of PSR[4]. Reference Level P2.2 stipulates that the scope of the review shall be clearly defined and as comprehensive as reasonably practicable with regard to significant safety aspects. P2.2 contains an enumerative list of 14 safety factors to be covered. Among these, equipment qualification, deterministic safety assessment, probabilistic safety assessment, hazard analysis and

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3 The value was derived from a deterministic approach by adding one degree of intensity to the maximum intensity earthquake observed in the region, i.e., the 1938Zulzeke-Nukerke earthquake with a local intensity I=5.5 and M=5.6. The DBE was therefore defined by I=6.5MMI. This approach is not in line with current practice and the WENRA (2021) Safety Reference Levels.

4 So far, WENRA did not publish Reference Levels specific to LTO.

safety performance are of prime importance for the assessment of a plant's safety with respect to external hazards.

Complementing Issue P, Issues E and F of the WENRA Safety Reference Levels (WENRA 2021) stipulate that design basis and design extension conditions of existing reactors shall be reviewed and updated regularly[5] (reference levels E11.1 and F5.1). Reviews of natural hazards are not addressed on the level of the Reference Levels but in WENRA's so-called guidance documents on external hazards. WENRA (2020a) specifies that *"the site specific hazards and the protection concepts against external hazards should be reviewed at least as part of the PSR"* and that the results of hazard reviews should be used in the reviews of both, the design basis and design extension conditions (WENRA 2020a, 2020b). The cited guidance documents on natural hazards provide more detailed information for hazard reviews. For earthquake, hazard reviews should account, inter alia, for novel data on seismic sources, newly discovered active or capable faults, new data on ground motion attenuation, and site effects (WENRA 2020b). Reviews of flooding hazards should particularly address man-made changes of physical geography and climate change (WENRA 2020c). Reviews of hazards by extreme weather should pay attention to non-stationary effects including climate change (WENRA 2020d).

In sum, WENRA requires that external hazards be addressed as part of the PSR, including reviews of the Design Basis and DEC conditions. The design basis of existing plants is not considered fixed by the initial plant design but rather as a "floating" value that can change over the life of a reactor in response to updated hazard assessments. The same applies to design extension conditions (DEC).

In 2014 WENRA published commonly agreed Safety Reference Levels (SRL) and guidelines for the consideration of natural hazards in the safety demonstration for existing reactors such as the Borssele NPP (WENRA 2014). In a later stage, WENRA enlarged the scope of the concerned Reference Levels to include external human-made hazards such as external explosion, fire or airplane crash (WENRA 2021, Issue TU, External Hazards). The WENRA Reference Levels are regarded binding by all WENRA member states including the Netherlands. WENRA (2020a-d) further provide detailed guidance on how to apply the Safety Reference Levels for natural earthquake, external flooding and extreme weather.

The Reference Levels and accompanying guidance cover the identification and assessment of external hazards, the definition of design basis events, the protection against design basis events, and the consideration of events more severe than the design basis (WENRA 2014; 2020a-d; 2021). The Reference Levels particularly stipulate that, for all hazards that apply to a site, design basis events shall be defined based on site-specific hazard assessment. The occurrence probability of these design basis events shall not exceed 10^{-4} per year in order

[5] WENRA understands "regular" as an ongoing activity in which PSR is a complementary tool to follow up this activity on a longer perspective (WENRA RHWG 2021, Reference Level A2.3)

to ensure a high level of protection against external hazards (WENRA 2014, Issue T4.; WENRA 2021, Issue TU4.)[6].

WENRA (2014, Issue T5.; 2021, Issue TU5.) further requires existing reactors being protected from design basis events. During design basis accidents, protection shall be sufficiently reliable to conservatively ensure that the plant is able to fulfil the fundamental safety functions[7]. This is to be achieved by applying reasonable conservatism providing safety margins in the design WENRA (2014; 2021, Issue E8.).

Consideration of phenomena more severe than the design basis events are stipulated in Issue T6. and TU6., respectively (WENRA 2014; 2021)[8]. Such events and phenomena are summarized under Design Extension Conditions (DEC). The Reference Levels require identifying and assessing the effects of events not covered by the design basis. Analyses shall include the assessment of hazard severity as a function of the related occurrence probability (when practicable) along with the impact of such events on the plant. The overall goal is to identify reasonably practicable improvements to increase the robustness and resilience of a plant that can be implemented for the prevention of severe accidents[9].

Issues T and TU of WENRA (2014) and (2021), respectively, clearly express that the design basis of a plant may change during its lifetime, e.g., due to a new hazard assessment that identifies higher severities of the design basis event (e.g., in terms of seismic ground motion or flood height)[10]. The same applies to DEC considerations. WENRA consequently requires that the design basis and DEC shall regularly be reviewed using both, a deterministic and probabilistic approach (WENRA, 2014; 2021; SRL E11.1 and F5.1). It is explained that *"regularly"* is understood as ongoing activity supported Periodic Safety Reviews on a longer perspective[11].

It is recommended to define, in the EIA Phase 1, a mandatory process of how external hazards have to be re-assessed and taken into account in EIA Phase 2. The process should be based on the agreed WENRA Safety Reference Levels (WENRA 2014; 2021), and relevant WENRA guidance. UMWELTBUNDESAMT (2023) formulated a similar recommendation: The EIS should describe the nuclear safety framework relevant to decide on the LTO. It should be presented how the recent updates of the regulations and guidelines by international institutions (IAEA, WENRA Safety Reference Levels, WANO) and Euratom are implemented in the Dutch legal framework. With respect to this recommendation EIA REPORT

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[6] Requirements for the definition of the design basis have to be read in conjunction with Issue E, Design Basis Envelope for Existing Reactors.

[7] Control of reactivity, cooling of the reactor core and spent fuel, confinement of radioactive material.

[8] Requirements for the definition of the design basis have to be read in conjunction with Issue F, Design Extension of Existing Reactors.

[9] Issue F of WENRA (2014; 2021) has the same requirement.

[10] WENRA (2014), Reference Level E1.1, Footnote 16: *„The design basis shall be reviewed and updated during the lifetime of the plant*"

[11] WENRA, 2014; 2021; SRL A2.3

(2024) only states that the NPP will have to demonstrate that the plant can continue to comply with all relevant Dutch requirements and international standards in the long term in Phase 2 of the EIA. The LTO decision will be made on the basis of regulations which will be in place at the time of the decision.

Coverage of recommendations formulated by UMWELTBUNDESAMT (2023)

In the preparatory phase of the current EIA, which was dedicated to the delineation of the scope of the investigation ("scoping"), UMWELTBUNDESAMT (2023) listed specific topics on which the environmental impact statement should provide information. These recommendations mostly seem to be covered by DUTCH NUCLEAR ENERGY ACT AMENDMENT DRAFT (2024) and the stipulations of focal points to be addressed in Phase 2 of the EIA (EIA REPORT 2024):

- Recommendation by UMWELTBUNDESAMT (2023): The EIS should describe the nuclear safety framework relevant to decide on the LTO. It should be presented how the recent updates of the regulations and guidelines by international institutions (IAEA, WENRA Safety Reference Levels, WANO) and Euratom are implemented in the Dutch legal framework.
- EIA REPORT (2024): The NPP will have to demonstrate that the plant can continue to comply with all relevant Dutch requirements and international standards in the long term in Phase 2 of the EIA. The LTO decision will be made on the basis of regulations which will be in place at the time of the decision. The current legal and policy frameworks for nuclear safety is outlined in table 8-2 of EIA REPORT (2024).
- Recommendation by UMWELTBUNDESAMT (2023): Potential impacts of climate change for the respective time periods (10 years, 20 years, indefinite) should be addressed. This should include higher temperatures of the Schelde, stronger and more frequent extreme weather situations like storms, floods, heavy rain etc.
- EIA REPORT (2024) identifies climate change and expected effects on external flooding and extreme weather as points to focus on in EIA Phase 2.
- Recommendation by UMWELTBUNDESAMT (2023): Climate change considerations should be included in the analysis for LTO. Explain these considerations together with the IAEA SSG-25 safety factor 6 and safety factor 7.
- EIA REPORT (2024) does not specifically address IAEA SSG-25.
- Recommendation by UMWELTBUNDESAMT (2023): The EIA should describe all relevant natural factors as well as man-made events, which could lead to accident conditions and the release of radionuclides into the environment. The EIS should describe, if and how the plant is able to withstand these impacts.
  EIA REPORT (2024) does not contain a list and descriptions of all natural and human-made external hazards that apply to the site. The authors of the current report understand that the task is due in EIA Phase 2. The recommendation is consequently repeated below.

6.3 Conclusions, questions and preliminary recommendations

EIA REPORT (2024) explains that the current Phase 1 of the Environmental Impact Assessment (EIA) solely addresses eliminating legal obstacles to ANVS considering a potential permit application from EPZ for the extension of operations of the Borssele NPP. A comprehensive treatment of external hazards and their effect on nuclear safety besides a few hazards (see below) is consequently not in the scope of the EIA Phase 1.

With respect to natural hazards EIA Phase 1 defines a few focal points for Phase 2. These exclusively pertain to the effects of climate change and the following natural hazards:

- Sea level rise, in connection with external flooding.
- Increasing maximum seawater temperature, in connection with reactor cooling.
- Increasing maximum air temperature, in connection with the cooling of safety-related systems.
- Increases of extreme weather events, such as more severe storms.

There is no further information in the EIA Phase 1 documents about whether and, if so, how other external hazards should be taken into account in EIA Phase 2 and the LTO process. Among the hazards not considered in EIA Phase 1 earthquake (vibratory ground motion) and the causally linked seismotectonic hazards liquefaction and dynamic compaction deserve particular attention.

Documents on Phase 1 of the EIA further do not provide information on the general process that will be followed up in Phase 2 and in the final decision on LTO. It is neither known if LTO will be linked to Periodic Safety Reviews nor if revisions of the hazard assessments for all site-specific external hazards, re-assessments of the design bases for external hazards and adequate DEC assessments are planned to be part of the future LTO process. With respect to the future process, it is recommended to link the LTO decision to Periodic Safety Reviews considering all WENRA Safety Reference Levels relevant to external hazards (Issue TU), design basis and DEC considerations (Issues E and F) and PSR (Issue P).

Questions:

Q28*: Please provide an outline of EIA Phase 2 and the envisaged process for deciding on the LTO for the Borssele NPP for the assessment on external hazards.*

Preliminary recommendations

PR16: EIA REPORT (2024, p. 109-110) describes the legal and policy frameworks for nuclear safety at a national and international level notably without referring to WENRA documents, most importantly the Safety Reference Levels for Existing Reactors, and other relevant documents. The Netherlands are member of

WENRA and committed to apply the Safety Reference Levels. It is therefore recommended to explicitly refer also to the framework of the WENRA Reference Levels and ensure that EIA Phase 2 and the LTO process comply with the WENRA regulations.

PR17: It is recommended to define, in the EIA Phase 1, a mandatory process of how external hazards have to be re-assessed and taken into account in EIA Phase 2. The process should be based on the agreed WENRA Safety Reference Levels (WENRA 2021), and relevant WENRA and IAEA guidance.

PR18: It is recommended to require for Phase 2 of the EIA and LTO a demonstration that all hazards and combinations of hazard that apply to the Borssele site must be identified by comprehensive site-specific hazard screening. WENRA (2020a) provides a non-exhaustive, yet extensive, list of natural and human-made hazards to be used as a starting point for screening. DECKER & BRINKMAN (2017) provide detailed information on hazard combinations.

PR19: It is recommended to add seismotectonic hazards (vibratory ground motion, liquefaction and dynamic compaction) to the focal points that require attention in Phase 2 of the EIA.

7 ACCIDENTS WITH THIRD PARTIES' INVOLVEMENT

7.1 Treatment in the EIA documents

The EIA documents do not address accidents with third parties´ involvement.

7.2 Discussion

The nuclear power plants currently in operation have a certain degree of protection against possible terrorist attacks due to their design, e.g. relatively thick outer walls and diverse and redundant safety systems. However, the Borssele nuclear power plant was built long before the attacks of September 11, 2001 and is therefore not sufficiently protected against such massive attacks. A terrorist attack on a nuclear power plant can trigger a severe accident with significant effects on the population.

After September 11, 2001, the German government commissioned various studies on the consequences of terrorist aircraft attacks on nuclear power plants. These studies are subject to strict confidentiality. Nevertheless, the summary of one study was published by the German environmental organization B.U.N.D. (BMU 2002). The study deals with five exemplary reference plants that cover the types of nuclear power plants operated in Germany. The three important impacts considered in such aircraft crashes are: impact of the aircraft, flying debris and kerosene fire. In doing so, several load cases are distinguished, two crash speeds: 175 m/s and 100 m/s and three aircraft types: large, e.g. Boeing 747; medium, e.g. Airbus 300; small, e.g. Airbus 320.

According to the study, a core meltdown accident is possible for a KWU PWR CL1 (like the Borssele NPP), in the event of a crash of almost all aircraft types and at both velocities. The exception is a targeted crash of a small aircraft at low speed. A deliberate crash would result in an extensive destruction of the reactor building. There is a possibility that engines and other rigid parts penetrate the building. The subsequent, very likely failure of the cooling system would result in a severe accident of the most dangerous category: a core meltdown accident with an open containment. The radioactive releases would be very high and would occur particularly early.

The increasing risk from ageing effects should also be noted: a recent study used numerical simulations to examine the influence of ageing on the effects of a military aircraft impact on a nuclear power plant. The results show that the ageing of a plant increases its vulnerability to large-area or localized penetrations. The greater the degradation of the materials, the lower the residual resistance and the greater the risk of wall perforation. At the same impact force, the strength of the aged containment is reduced by about 30 %. (FRANO 2021)

The design differences between old and newer NPPs result in different protection levels against deliberate terror attack with a commercial aircraft. Because of the fact that the wall thickness of the older constructions lines 1 and 2 is only 0.60 to 1 meter, the vulnerability of the reactor building is relatively high. For example, the EPR's 1.8-meter-thick outer reinforced concrete shell is designed to withstand the impact of a large passenger aircraft.[12]

It was explained in ANVS (2020a) that various studies concerning an aircraft crash were conducted, and all completed in 2018. However, the results are not mentioned.

According to WENRA (2013), a targeted crash of an airliner is not expected to lead to a core meltdown accident for new NPPs and therefore, according to the WENRA safety objective (O2) for new reactors, may only have minor radiological consequences. To demonstrate this, the effects of direct and secondary impacts of the aircraft accident are to be considered (vibrations/shocks, combustion and/or explosion of the aircraft fuel). In addition, buildings or parts of buildings containing nuclear fuel and safety-related safety equipment should be designed in such a way that no kerosene can penetrate them.

In addition to an attack using a commercial aircraft, a number of other attack scenarios are conceivable for a terrorist attack from the air. Scenarios for terrorist attacks from the air could include, for example, the crash of a helicopter loaded with explosives or the dropping of a bomb from a helicopter. The drone overflights in France in the fall of 2014 highlighted weaknesses in the air surveillance of French NPP respectively and, in particular, in the defense against such potential attacks from the air as it was not possible to stop the overflights or identify the responsible group. In the fall of 2014, 31 drone overflights were recorded over 19 French nuclear facilities.[13] Drones can be used, for example, as in military applications, to prepare or support a terrorist attack. (GP 2014)

The targeted terrorist attack of September 11, 2001 made it clear that even extreme terrorist activities can pose a concrete threat, which led to a tightening of security requirements for nuclear facilities. However, Russia's attack on Ukraine has given rise to scenarios that were previously considered unrealistic. The risk of catastrophic accidents has increased again. Russia has made it clear that international rules prohibiting acts of war around nuclear power plants can only be upheld as long as all parties feel bound by them. Nuclear facilities pose a particular threat in such cases. (BASE 2022)

The long-running conflict in the Ukraine is leading to the further proliferation of military weapons, and with it, an increased risk of terrorist attacks.

Terrorist groups have already begun to use drones to conduct and coordinate attacks. The massive increase in the number of form factors, capabilities, ease

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[12] https://www.grs.de/de/glossar/europaeischer-druckwasserreaktor-epr

[13] It is still unclear who was controlling the drones.

of access and ease of operation of drones at low cost will make them the weapon of choice for future terrorists.

Nuclear Threat Initiative (NTI)

The US Nuclear Threat Initiative (NTI) assessed the measures taken by different countries to protect against terrorist attacks and sabotage in their nuclear facilities in the so-called Nuclear Security Index 2023. The NTI Index does not evaluate the specific measures taken at individual facilities, but rather the measures taken by the government and the legal requirements. In the NTI Index, 100 corresponds to the highest possible score and thus to the fulfillment of the current security requirements.

In the Nuclear Safety Index 2023, the Netherlands ranks 6th out of 47 countries with a total score of 86 points. However, low scores are given for "security culture" (50) and "protection against insider threats" (73). These low scores indicate weaknesses in the protection. (NTI 2024)

International Physical Protection Advisory Service (IPPAS)

The IAEA supports states in protecting their civilian nuclear materials and facilities by means of peer review missions conducted by its International Physical Protection Advisory Service (IPPAS). An IPPAS mission is an assessment of existing practices in a state in light of relevant international instructions and IAEA publications on nuclear security (IAEA 2021a). In October 2023, an IPPAS mission took place in the Netherlands, the results are not known. (IAEA 2024)

Coverage of recommendations formulated by UMWELTBUNDESAMT (2023)

It was requested in the expert statement to the scoping phase that the EIA Report should describe if and to what extent the shell of the reactor building must be able to withstand an airplane crash. However, this information is not provided.

7.3 Conclusions, questions and preliminary recommendations

Terrorist attacks and acts of sabotage can have significant impacts on nuclear facilities and cause severe accidents – also on the Borssele NPP. Nevertheless, they are not mentioned in the provided EIA documents. In comparable EIA Reports such events were addressed to some extent. Although precautions against sabotage and terror attacks cannot be discussed in detail for reasons of confidentiality, the necessary legal requirements should be set out in the EIA documents.

Information regarding the issue of terror attacks would be of great interest, considering the large consequences of potential attacks. In particular, the EIA documents should include detailed information on the requirements for the design against the targeted crash of a commercial aircraft. This topic is in particular important, because reactor building of the Borssele NPP is vulnerable against airplane crashes. The reactor building should protect the plant against attacks from outside. However, the wall thickness at the Borssele NPP is only about 0.6 m to 1.0 m. For example, the EPR's 1.8-meter-thick outer reinforced concrete shell is designed to withstand the impact of a large passenger aircraft.[14]

A recent assessment of the nuclear security in the Netherlands points to shortcomings compared to necessary requirements for nuclear security. Low scores for "Insider Threat Prevention" and "Security Culture" indicate deficiencies in these issues. (NTI 2024)

Military action against nuclear facilities is another danger that needs special attention in the current global situation. Furthermore, the increasing availability and performance of drones is raising the potential threat to nuclear facilities.

Questions:

Q29: *What are the protection requirements of the Borssele nuclear power plant with regard to the intentional crash of a commercial aircraft?*

Q30: *What external attacks do the reactor building and other safety-related buildings have to be designed to withstand? Is this protection still guaranteed despite adverse ageing effects?*

Q31: *What were the main results of the IAEA International Physical Protection Advisory Service (IPPAS) mission conducted in 2023?*

Q32: *How is the current threat situation for nuclear facilities in the Netherlands assessed?*

Q33: *How is the result of the Nuclear Security Index 2023 for the Netherlands assessed? Are improvements planned with regard to "Security Culture" and "Insider Threat Prevention"?*

Q34: *Have any studies been or will be carried out on the threat posed by newer technologies, in particular potential attacks using civilian or military drones?*

Preliminary recommendations

PR20: The EIA documents should present the general requirements with respect to the protection against the deliberate crash of a commercial aircraft and other terror attacks and acts of sabotage.

[14] https://www.grs.de/de/glossar/europaeischer-druckwasserreaktor-epr

PR21: In the light of the special situation in Ukraine, and availability of new technologies, in particular Drones, the effects of third parties (terrorist attacks or acts of sabotage of the plant) should be given high priority.

PR22: The protection against the "threat of insiders" and the "security culture" should be improved.

8 TRANSBOUNDARY EFFECTS

8.1 Treatment in the EIA documents

The EIA Report describes transboundary effects from emissions during normal operation as below the legal limits in Belgium, which is the nearest neighbouring country, and therefore negligible for all other countries, too. (EIA REPORT 2024, p. 105)

For design basis accidents and beyond design basis accidents, the EIA Report states that Borssele meets the legal criteria and risk criteria. The safety analyses underpinning this will have to be renewed for operation after 2033. In this process, the transboundary effects will have to be considered once again. (EIA REPORT 2024, p. 123)

Cooling water discharges might lead to transboundary effect during normal operation, but their extent has not been assessed yet. (EIA REPORT 2024, p. 141)

8.2 Discussion

As discussed in chapter 5, the information about Beyond Design Basis Accidents (BDBA) is very limited. Neither the accident scenarios nor the possible source terms are provided. Core-melt accidents can cause a failure of the containment. These scenarios are associated with large releases.

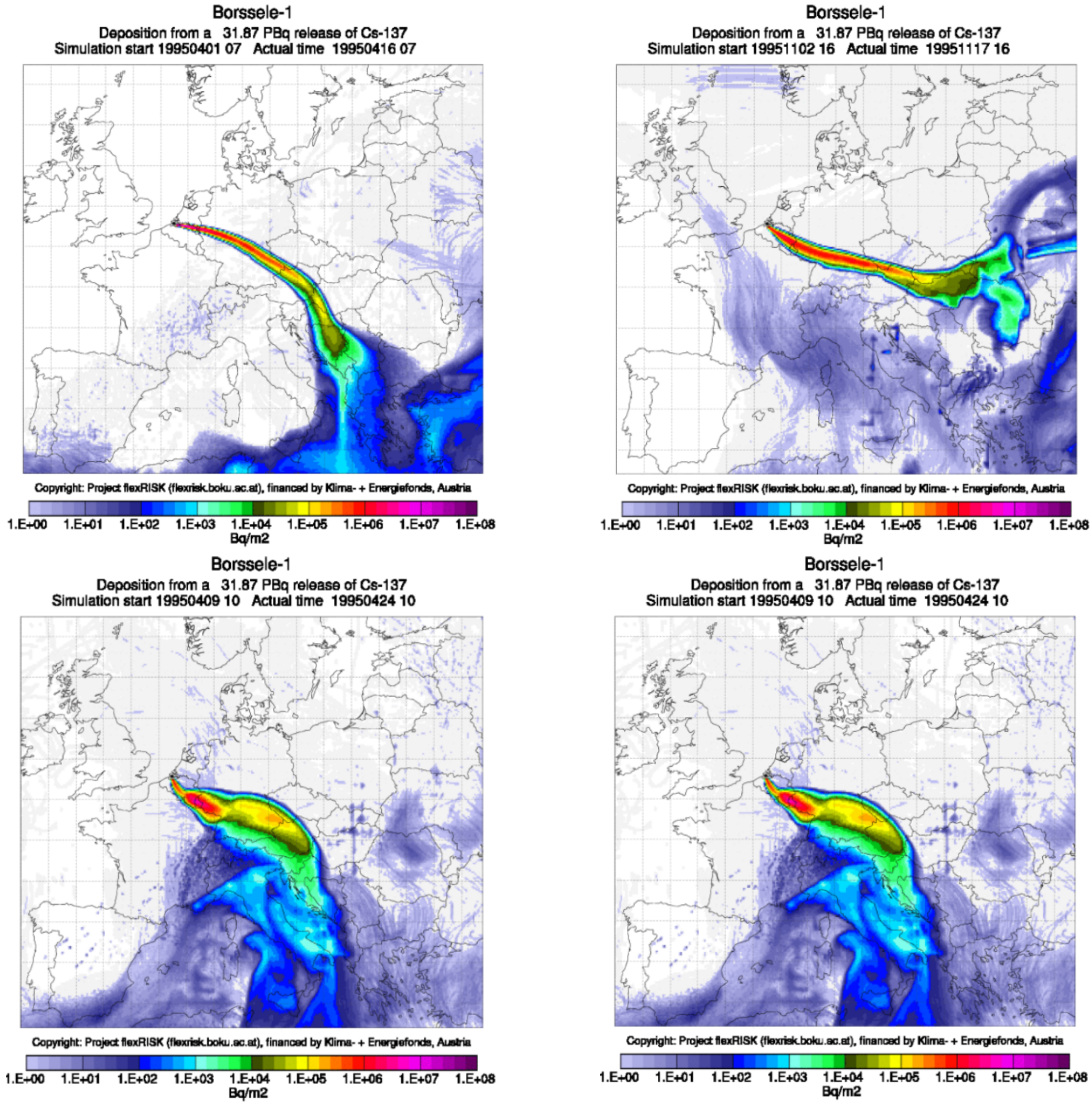
The project flexRISK[15] identified source terms for severe accidents, for Borssele a possible source term of 31.87 PBq Cs-137. This source term was calculated with respect to the behavior of the plant in case of a severe accident and the possible release.

Calculations of the flexRISK project can be used for the estimation of possible impacts of transboundary emission of Borssele. The flexRISK project modelled the geographical distribution of severe accident risk arising from nuclear power plants in Europe. Using source terms and accident frequencies as input, for more than 2,000 meteorological situations the large-scale dispersion of radionuclides in the atmosphere was simulated.

15 http://flexrisk.boku.ac.at/en/projekt.html

Figure 4: Weather-related deposition with Cs-137 in Bq/m2 by a severe accident at Borssele. Source: https://flexrisk.boku.ac.at/en/evaluation.phtml#form

Weather-related deposition with Cs-137 after an accident at Borssele



Source: https://flexrisk.boku.ac.at/en/evaluation.phtml#form

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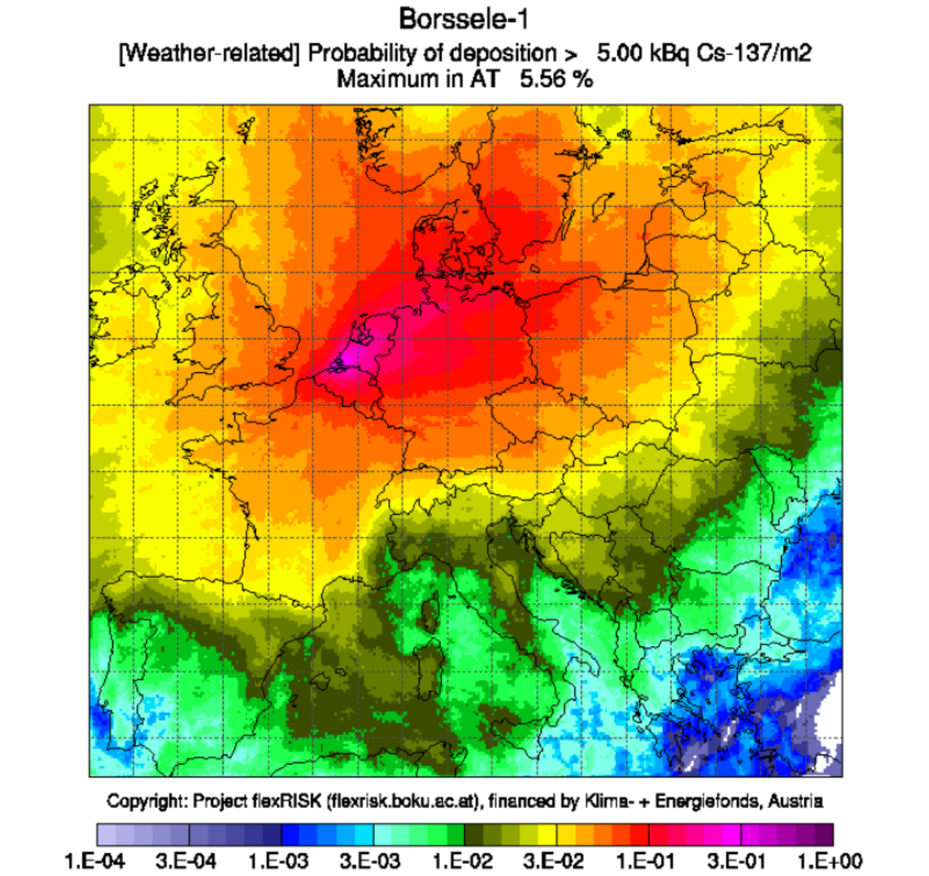
This flexRISK figure shows four different weather situations in which Austria could be severely contaminated by this assumed accident in Borssele. The contamination could reach up to a few hundred kBq/m² (light red colour).

flexRISK determined the weather-related probability for a contamination of Austrian territory with more than 5 kBq Cs-137/m² with 5.56 (see Figure 5). The weather-related probability for a contamination with more than 37 kBq Cs-137/m² is 2.12%, for more than 185 kBq Cs-137/m² 0.47%, respectively.

Figure 5: Weather-related probability for a contamination exceeding 5 kBq Cs-137/m² by a severe accident at Borssele. Source: https://flexrisk.boku.ac.at/en/evaluationAggUnit.phtml#form



Source: *https://flexrisk.boku.ac.at/en/evaluationAggUnit.phtml#form*

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These probabilities might be low, but in Austria even lower contamination triggers agricultural countermeasures. These measures include earlier harvesting, closing of greenhouses and covering of plants, putting livestock in stables etc. A catalogue of countermeasures for radiological crisis situations is used, which requires the introduction of agricultural protection measures even in the case of low levels of contamination (MASSNAHMENKATALOG 2022). This catalogue includes, among others, measure V06 ("Immediate harvesting of marketable products, in particular of storable products") with its associated (forecast) levels:

Table 3: Levels for the agricultural countermeasures V06 (MASSNAHMENKATALOG 2022, p. 37f.)

	Time-integrated air concentration for dry deposition		**Soil contamination**		**Air concentration for wet deposition**	
	Iodine $Bq*h/m^3$	Cs $Bq*h/m^3$	Iodine Bq/m^2	Cs Bq/m^2	Iodine Bq/m^3	Cs Bq/m^3
Start of measure V06	170	360	700	650	12	7

A contamination of 5 kBq Cs-137/m^2 like Table 3 is much higher than the level for the Cs contamination in the above table, therefore agricultural countermeasures could be necessary on Austrian territory in case of a severe accident at the Borssele site.

To exclude the possibility of transboundary severe impacts, including the need for agricultural countermeasures, dispersion calculations and dose calculations should be carried out for distances including the Austrian territory, with the goal to compare the results with the Austrian levels from the catalogue of countermeasures (MASSNAHMENKATALOG 2022), but also with the dose levels specified in the Austrian Emergency Plan (BMK 2024, p. 131f.).

8.3 Conclusions, questions and preliminary recommendations

Neither scenarios for severe accidents nor the possible source terms are provided in the EIA documents. Significant adverse effects for Austria were ruled out anyway. However, this cannot be verified.

Calculations with the highest possible source term and under the assumption of the most negative weather condition for Austrian territory should be provided in EIA phase 2.

Calculation results for the ground and air contamination in case of a severe core-melt accident would be necessary in order to be able to assess whether agricultural protection measures would have to be initiated in Austria.

Questions:

Q35: *For assessing the consequences of severe accidents on Austrian territory we kindly ask for calculation results comparable to contamination levels in MASSNAHMENKATALOG (2022, p. 37f.) This will allow Austria to assess if in case of a severe accident agricultural measures will need to be taken.*

Preliminary recommendations

PR23: It is recommended to calculate the transboundary effects for a severe accident with failure of the containment, regardless of the determined probability of occurrence, as long as this is physically possible.

9 LIST OF QUESTIONS AND PRELIMINARY RECOMMENDATIONS

9.1 Procedure and alternatives

9.1.1 Questions

Q1: *For how long is the lifetime extension foreseen?*

9.1.2 Preliminary recommendations

PR1: It is recommended that alternatives are discussed and assessed for their environmental impacts in the EIA phase 2. This encompasses alternatives for energy production but also for different durations of lifetime extensions.

PR2: The electricity generation system will change in the upcoming future. Due to the increase of the use of renewable energy generation sources load following operation might be a challenge for the plant. The EIA phase 2 should discuss if and how the plant will be integrated into a generation system, which could require load following operation. A description of the assessment of safety relevant components of the plant should elaborate how stress factors, due to load following operation, had been analysed and what were the related results.

PR3: EIA phase 2 should include an assessment of all facilities and their infrastructure and transportation routes with hazardous and potentially dangerous goods that could lead to a danger for the NPP Borssele.

9.2 Nuclear waste management

9.2.1 Questions

Q2: *What capacity has the HLW storage HABOG for the different types of HLW?*

Q3: *To which degree is the HABOG filled now, and what is foreseen until 2033?*

Q4: *When will a contract with Orano be made for the reprocessing of spent fuel from the lifetime extension? What will happen if no contract can be concluded?*

Q5: *Will LILW from the lifetime extension be stored at LOG or MOG?*

Q6: *What capacity have the LILW interim storage facilities LOG and MOG?*

Q7: *To which degree is the LOG filled now, and what is foreseen until 2033?*

Q8: *What is the design life for HABOG, LOG and MOG?*

Q9: *How will the safety and security of all interim storages over more than 100 years be demonstrated?*

9.2.2 Preliminary recommendations

PR4: It is recommended to provide in the EIA phase 2 sufficient evidence for safe management of the radioactive waste from lifetime extension including the high level waste from reprocessing.

9.3 Long-term operation of reactor type

9.3.1 Questions

Q10: *What are the results of the embrittlement of the reactor pressure vessels (RPVs) for the Borssele NPP? On the basis of which well-founded investigations are the safety margins considered sufficient and for which period of time?*

Q11: *Is there a systematic evaluation of the design deviations from the current international safety standards and requirements envisaged?*

Q12: *When will the WENRA 2020 RL be fully implemented in the Dutch regulations? Is the application of the RL binding for the possible life-time extension of the Borssele NPP? When will a review be conducted if the RL will be met for the Borssele NPP?*

Q13: *Which WENRA Documents are mandatory for the lifetime extension? Which IAEA Documents are mandatory for the lifetime extension?*

Q14: *What experience has already been gained with the newly formed TSO? Is it equipped with sufficient resources to accomplish the challenging task?*

Q15: *In which systems it is not technically possible or is avoided for economic reasons to backfit physical separation of safety systems?*

Q16: *Which safety systems of different levels of the defense in depth concept are not independent of each other at the Borssele NPP?*

Q17: *What are the main findings of the fourth PSR? Which modernization measures and in which time frame are envisaged?*

Q18: *What technically feasible improvements to meet modern safety requirements were not considered "reasonably practicable" for the Borssele nuclear power plant as part of the fourth PSR?*

9.3.2 Preliminary recommendations

PR5: The EIS should describe the nuclear safety framework and its provisions, which are relevant to decide on the LTO. It should be presented how the recent updates of the regulations and the corresponding recommendations elaborated by international institutions (IAEA, WENRA Safety Reference Levels, WANO) and Euratom are implemented in the Dutch legal framework.

PR6: The EIS should present in detail the findings of the fourth PSR (2013-2022), which is a prerequisite to decide on the intended long term operation in general.

PR7: It is recommended that the remedy of the identified weaknesses of the fourth PSR have to be prerequisite for approval for a further lifetime extension.

PR8: The implementation of the 2020 WENRA RLs should be regarded as a prerequisite for a possible lifetime extension but should also be made mandatory in the procedure for amending the Atomic Energy Act.

PR9: Before the law is amended, it should be evaluated if the many corrosion events identified by the OSART team can be effectively counteracted or if physical and technical aging not only makes this difficult but even excludes it.

PR10: It is recommended to undertake a comparison of the design and measures of the Borssele NPP with all requirements of WENRA SRL F. In case of deviations will be found and accepted the reasons for this decision should be explained.

PR11: It is recommended to implement all technically available safety improvements to prevent accidents.

PR12: It is recommended provide the following further information:

- a detailed description of the safety systems, including information on requirements for the important safety-relevant systems and components. Furthermore, detailed description of the measures taken to control severe accidents or to mitigate their consequences.
- Information about the applied national requirements and international recommendations.
- comprehensible presentation and overall assessment of all deviations from the current state of the art in science and technology. This presentation should include:
  - All deviations from the modern requirements for redundancy, diversity and independence of the safety levels.
  - Incompleteness of the database and plant documentation used.
  - Presentation of all safety assessments or parameter definitions by personal expert assessments (“engineering judgement”).
  - Presentation of the general dealing of uncertainties and nonknowledge and its effects on risk

  - Deviations from the state of the art in science and technology with regard to the detection methods used, the technical estimates and calculation procedures.
  - The safety margins available for the individual safety-relevant components and their respective ageing related changes compared to the original condition.
- Information to the ageing management programme, including
  - The very important safety issue of the ageing of the RPVs (embrittlement), including definition and justification of appropriate safety margins.
  - Evaluation of the conditions of the RPV internals and head penetrations including trends of events, and envisaged exchange measures.
  - Evaluation of the conditions of components of the primary circuit components and of the electrical installations including trends of events, and envisaged exchange measures.
- Regarding operation experience, the EIA documents should present an evaluation of safety relevant events including the lessons learned.

9.4 Accident analysis

9.4.1 Questions

Q19: *What are the source terms of the possible BDBAs calculated in the probabilistic safety analyses 2 (PSA 2) including releases from the spent fuel pools?*

Q20: *What is the source term and the accident scenario of the BDBA that is chosen to calculate possible trans-boundary consequences? What is the technical justification for the use of this BDBA?*

Q21: *Which design basis accidents can develop into a beyond design basis accident?*

Q22: *Which accidents scenarios with the loss of containment integrity or containment bypass are physically possible?*

Q23: *How could a melt-through of the basement due to a core meltdown accident be reliably prevented?*

Q24: *Has a DEC-B analysis been performed to identify reasonably practicable measures to mitigate the consequences of significant fuel damage or conditions that could lead to early or large radioactive releases, unless such damage or conditions have been determined to be extremely unlikely with a high degree of confidence?*

Q25: *Are target values for the probability of design basis accidents, design extension conditions (DEC) without significant core damage (DEC-A) and with core melt (DEC-B) specified in the Dutch regulations? What are the respective values for the Borssele NPP? Were deterministic analyses also carried out in each case?*

Q26: *When will an analysis of internal events be carried out in accordance with WENRA RL SV (WENRA 2021)? Did these safety cases already form part of the fourth PSR?*

Q27: *What is the technical design of the IVR concept? What studies have been carried out on its reliability and with which results?*

9.4.2 Preliminary recommendations

PR13: Based on 2014/87/Euratom Article 8a existing nuclear installations should reach a safety level as close as possible to new nuclear power plants. The approach to be in line with 2014/87/Euratom should be presented the EIS. The EIS should describe the differences between Borssele NPP - for each of the Alternatives 1, 2 and 3, in comparison to new nuclear power plants, with respect to the exclusion of early and large releases. This should include a description of releases of nuclides under design base and beyond design base accidents in comparison to new nuclear power plants. (See also UMWELTBUNDESAMT 2023)

PR14: It is recommended to use the WENRA Safety Objectives for new NPP to identify reasonably practicable safety improvements for the Borssele NPP. It is recommended to use the concept of practical elimination for this approach.

PR15: It is recommended to provide the following information concerning accident analyses and the results of the PSA (Level 1, 2 und 3):

- Core damage frequency (CDF) and large (early) releases frequency (L(E)RF)
- Contribution of internal events as well as internal and external hazards to CDF and L(E)RF
- List of the beyond design basis accidents (BDBAs) and severe accidents
- Source terms of all possible BDBAs and sever accidents
- Time spans to restore the safety functions after the loss of heat removal and/or station-blackout and cliff edge effects.

9.5 External hazards

9.5.1 Questions:

Q28: *Please provide an outline of EIA Phase 2 and the envisaged process for deciding on the LTO for the Borssele NPP for the assessment on external hazards.*

9.5.2 Preliminary recommendations

PR16: EIA REPORT (2024, p. 109-110) describes the legal and policy frameworks for nuclear safety at a national and international level notably without referring to WENRA documents, most importantly the Safety Reference Levels for Existing Reactors, and other relevant documents. The Netherlands are member of WENRA and committed to apply the Safety Reference Levels. It is therefore recommended to explicitly refer also to the framework of the WENRA Reference Levels and ensure that EIA Phase 2 and the LTO process comply with the WENRA regulations.

PR17: It is recommended to define, in the EIA Phase 1, a mandatory process of how external hazards have to be re-assessed and taken into account in EIA Phase 2. The process should be based on the agreed WENRA Safety Reference Levels (WENRA 2021), and relevant WENRA and IAEA guidance.

PR18: It is recommended to require for Phase 2 of the EIA and LTO a demonstration that all hazards and combinations of hazard that apply to the Borssele site must be identified by comprehensive site-specific hazard screening. WENRA (2020a) provides a non-exhaustive, yet extensive, list of natural and human-made hazards to be used as a starting point for screening. DECKER & BRINKMAN (2017) provide detailed information on hazard combinations.

PR19: It is recommended to add seismotectonic hazards (vibratory ground motion, liquefaction and dynamic compaction) to the focal points that require attention in Phase 2 of the EIA.

9.6 Accidents with third parties' involvement

9.6.1 Questions

Q29: *What are the protection requirements of the Borssele nuclear power plant with regard to the intentional crash of a commercial aircraft?*

Q30: *What external attacks do the reactor building and other safety-related buildings have to be designed to withstand? Is this protection still guaranteed despite adverse ageing effects?*

Q31: *What were the main results of the IAEA International Physical Protection Advisory Service (IPPAS) mission conducted in 2023?*

Q32: *How is the current threat situation for nuclear facilities in the Netherlands assessed?*

Q33: *How is the result of the Nuclear Security Index 2023 for the Netherlands assessed? Are improvements planned with regard to "Security Culture" and "Insider Threat Prevention"?*

Q34: *Have any studies been or will be carried out on the threat posed by newer technologies, in particular potential attacks using civilian or military drones?*

9.6.2 Preliminary recommendations

PR20: The EIA documents should present the general requirements with respect to the protection against the deliberate crash of a commercial aircraft and other terror attacks and acts of sabotage.

PR21: In the light of the special situation in Ukraine, and availability of new technologies, in particular Drones the effects of third parties (terrorist attacks or acts of sabotage of the plant) should be given high priority.

PR22: The protection against the "threat of insiders" and the "security culture" should be improved.

9.7 Transboundary effects

9.7.1 Questions

Q35: *What consequences will a severe accident have on Austrian territory? We kindly ask for calculation results comparable to contamination levels in MASSNAHMENKATALOG (2022, p. 37f.) This will allow Austria to assess if in case of a severe accident agricultural measures will need to be taken.*

9.7.2 Preliminary recommendations

PR23: It is recommended to calculate the transboundary effects for a severe accident with failure of the containment, regardless of the determined probability of occurrence, as long as this is physically possible.

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13 GLOSSARY

AMP .... Ageing Management Programme

ANVS .... Authority for Nuclear Safety and Radiation Protection

BBC..................................... Borssele Benchmark Committee

BDBA.................................. Beyond Design Base Accident

BMK.................................... Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology

Bq .... Becquerel

CDF..................................... Core Damage Frequency

CL.. Construction Line

COVRA................................ Central Organisation for Radioactive Waste, Dutch Waste Management Organisation

Cs.. Caesium

DBA .... Design Base Accident

DBE .... Design Basis Earthquake

DEC..................................... Design Extension Conditions

DGR .... Deep geological repository

DiD...................................... Defence in Depth

EIA .... Environmental Impact Assessment

EIA .... Environmental Impact Statement, now: EIA Report

EIS....................................... Environmental Impact Statement (related to Stage 2 of the EIA)

ENSREG .... European Nuclear Safety Regulators Group

g .... Gravitational Acceleration

GKN .... NPP Neckarwestheim, Germany

GRS..................................... Gesellschaft für Reaktorsicherheit, Germany

HABOG............................... Hoogradioactief AfvalBehandelings- en OpslagGebouw , High level radioactive waste treatment and storage building

HLW.................................... High level waste

I .... Iodine

IAEA .... Internationals Atomic Energy Agency

IVR .... In Vessel Retention

kBq .... KiloBecquerel

KWU .... Kraftwerksunion

LILW.................................... Low and intermediate level waste

LTO .... Long-term operation

MOG.................................... Multifunctioneel OpslagGebouw, LILW interim storage

mSv.................................... MilliSievert

MWe .... MegaWatt electric

MWth .... MegaWatt thermic

NAcP.................................... National Action Plan

NPE.................................... National Energy System Plan

NPP.................................... Nuclear Power Plant

NRPA .... Nuclear waste management programme

NTI .... Nuclear Threat Initiative

PGA.................................... Peak Ground Acceleration

PSA .... Probabilistic Safety Assessment

PSR .... Periodic Safety Review

PWR.................................... Pressurized Water Reactor

RHWG.................................... Reactor Harmonization Working Group

RL.................................... Reference Level

RPV .... Reactor Pressure Vessel

SEA .... Strategic Environmental Assessment

SG .... Steam generator

SGTR.................................... Steam generator tube rupture

SSC .... Systems, Structures and Components

TPR .... Topical Peer Review

TSO .... Technical Support Organisation

UNECE.................................... United Nations Economic Commission for Europe

WENRA.................................... Western European Nuclear Regulator's Association

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